BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

VOLUME XII
1915, 1916, 1917

CONTRIBUTIONS TO THE NATURAL HISTORY SURVEY OF ILLINOIS
MADE UNDER THE DIRECTION OF

STEPHEN A. FORBES

1918

1915-17

SCHNEPP & BARNES. STATE PRINTERS
SPRINGFIELD, ILL.
1918.
8040—600

CONTENTS

PAGE

ERRATA AND ADDENDA

Page 5, first column: line 2, for *Sheperdia* read *Shepherdia;* line 11, for *americana* read *americanus.*

Page 9, line 5 from bottom, for *XVII* read *X.*

Page 42, line 4 from bottom of key, for *Pyromorphidae* read *Eucleidae.*

Page 73, line 7 from bottom of key, for *or* read *and seldom.*

Page 100, just below key, insert as follows:—

The following species were examined:

Lophoptilus eloisella Clemens

Laverna brevivittella Clemens

Page 107, lines 8 and 9 from bottom, page 108, line 10 from bottom, and page 110, line 10, for *Cucullianae* read *Cuculliinae.*

Page 110, line 8 from bottom, dele Polia.

Page 112, line 19 from bottom, for *Metathoracic* read *Mesothoracic.*

Page 129, line 8, for *never* read *sometimes.*

Page 131, at end of second line insert Paleacrita Riley.

Page 158: first column, after Paleacrita, 127, add 131; second column, after Polia dele 110.

Page 170, line 4, for *Strayiomyiidae* read *Stratiomyiidae.*

Page 243, line 2, for *alternata* read *alternatus.*

Page 307: line 5 from bottom, for *with* read *and;* line 16 from bottom, for *Homeodactyla* read *Homoeodactyla.*

Page 314, line 15 from bottom, for *Cecidomyiidae* read *Coenomyiidae.*

Page 321, line 12 from bottom, for *Stratomyia* read *Stratiomyia.*

Page 324, line 6, for *pantherina* read *pantherinus.*

Page 370, line 18, for *Empidoidea* read *Empididoidea.*

Page 428, line 8 from bottom, for *Mesnotum* read *Mesonotum.*

Page 461, line 10 from bottom, for *Aeshnide* read *Aeshnidae.*

Page 478, line 13 from bottom, for *vigilas* read *vigilax.*

Page 519, line 2, dele *side.*

Page 528, line 10, for *caruncluatum* read *carunculatum.*

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., L.L.D.,
DIRECTOR

VOL. XII. SEPTEMBER, 1915 ARTICLE I.

THE RELATION OF EVAPORATION AND SOIL MOISTURE TO PLANT SUCCESSION IN A RAVINE

BY

FRED THEODORE ULLRICH

GLENCOE, ILLINOIS, AND VICINITY

Article I.—*The Relation of Evaporation and Soil Moisture to Plant Succession in a Ravine.* By Fred Theodore Ullrich.*

Introduction

For some time geologists have surmised that differences in the evaporative power of the air and the soil-moisture content account for the succession of vegetation that accompanies the physiographic changes in the development of a ravine. In order to determine whether or not this surmise can be supported by experimental data, this study was made during the summer of 1913. The ravine selected for investigation was the McLeish ravine, which lies in the southeastern part of the beautiful village of Glencoe, about sixteen miles north of Chicago. It is mapped in the Chicago folio of the United States Geological Survey as a part of the Evanston-Waukegan region. The general geographic features of this region are the moraine plain or rolling upland, the present shore, and the lake plain with its associated beach ridges. The rolling upland which constitutes the larger part of this area is glacial in origin, consisting of the usual glacial drift, clay, sand, gravel, and boulders, and rises more than sixty feet above the level of the lake. Since the ice sheet retreated, some of the glacial material has been reworked by rivers, waves, and winds, and thus is stratified. The heterogeneity in the composition of the drift and the resulting differences in the resistance to the forces of corrasion, and the great elevation of the upland above the level of the lake have furnished and are furnishing excellent conditions for the development of ravines. Of the many that have been carved in this upland, the McLeish ravine, although one of the smaller, may be considered a good representative.

Physiography of the McLeish Ravine

(Plate XVIII)

It would be foreign to this study to give a complete exposition of the geology and physiography of the ravines of this upland region. Such a presentation is given by Atwood and Goldthwait ('08). However, an intelligent appreciation of the method and results of this study requires a brief description of the location and direction of the

*Accepted by the University of Chicago for the degree of Master of Arts in Botany.

courses of the ravine and its tributaries, the probable origin of the ravine, and its present physiography. The McLeish ravine is formed by the confluence of two gullies, the heads of which, if measured in straight distance, are each about 2000 feet inland. From the junction of the two gullies the ravine has an almost easterly direction for about 1500 feet, until it reaches its main tributary from the south, when it continues in a northeasterly direction for about 800 feet to the point where it empties into the lake. From the south, in addition to the main tributary, the ravine receives a number of small gullies.

Physiographers have summarized under three heads the successive stages in the cycle of the development of such a ravine as the one here considered: the V-shaped valley, with slopes normally convex; the U-shaped valley, a stage of development where detritus descending the slopes is not all carried away by the stream, and consequently the valley is being widened faster than it is deepened; and, finally, the valley with a broad bottom, in which transformation is affected partly by erosion and partly by deposition in the ravine. The tributaries of the McLeish ravine are mostly in the first stage of the cycle, while the main course of the ravine shows that it is passing from the V-shaped stage into the U-shaped stage.

It is altogether likely that this ravine had its infant development accelerated by swampy depressions in the upland near to the lake. Such swamps or marshes within reasonable distance from the head of the cliff of the lake shore would, through seepage, make materials between them and the lake shore so mobile that the head of the gully would work inland with unusual rapidity. The influence of such depressions in ravine formation can at present be seen in the vicinity of Glencoe.

In the weekly visits to this ravine, the physiographic changes due to weathering, wash, and lateral corrasion were decidedly noticeable. Some of the records made at the time of observation read as follows: (1)—during a heavy rain—small streams of clay are flowing leisurely to the bottom of the stream; (2) it will be only a matter of a relatively short time when two large hard-maple trees will become so undermined by the streams caused by heavy rains as to fall across the channel; (3) a large slump of clay has been deposited at the bottom of the ravine during the preceding week, due to the undermining action of the stream and to the percolating of the water through the soil above the cavity; (4) in following the ravine, from the point where the main tributary enters, to its mouth, a gradation of detritus ranging from boulders and cobblestones to sand is passed (Pl. I, Fig. 1); (5) the waves of the lake usually maintain a bar of shingle and sand across the mouth of the ravine, which results in the formation

of a pool of water which gradually filters into the lake as more water is brought down the ravine; (6) after heavy rains the channel is invariably reopened by sweeping the materials which form the barrier into the lake. This gives some conception and appreciation of the force of the current as an active agent in modifying the physiography of the ravine. These statements indicate the dynamic character of the McLeish ravine.

Succession of Vegetation

After this brief consideration of the geographical and physiographical features, we may now turn our attention to the vegetation. Cowles ('01), in his "Plant Societies of Chicago and Vicinity," calls attention to the fact that the slopes of the embryonic V-shaped ravine, after they attain sufficient stability, develop a carpet of luxuriant vegetation. He says: "In a comparatively few years the vegetation leaps, as it were, by bounds through the herbaceous and shrubby stages into a mesophytic forest, and that, too, a maple forest, the highest type found in our region." This quotation describes admirably what has taken place in the greater portion of this ravine and its tributaries. A somewhat detailed examination of the summer and fall flora of the ravine showed that the slopes of the gullies leading into the ravine (Pl. I, Fig. 2) were nearly or quite devoid of vegetation, with the exception of some mosses on the north-facing slopes. A wash or gully near the mouth of the ravine, comparable to the head of a ravine working inland, had rather severe conditions for plant growth in the upper half of its slope. Owing to the extreme exposure to light, wind, and heat, and to the absence of humus in the soil, only a few of the xerophytic pioneers succeeded in establishing themselves. Near the foot of this wash a more or less stable miniature plateau (Pl. II, Fig. 3) was formed. On this, during the latter part of the summer, there was a great variety and profusion of asters,—one of the most pleasing sights in the ravine at that time. The slopes with mesophytic forest vegetation, with its usual undergrowth, constitute the most general feature of the ravine. This mesophytism in a ravine is regarded by ecologists as only temporary. After the vertical cutting has reached base-level, and as lateral cutting reduces the inclination of the slope, removing the humus and increasing the exposure, there is retrogression from mesophytism to xerophytism. This tendency towards xerophytism is checked through the development of vegetation, which finally results in the establishment of the permanent mesophytic climax of the region. In the ravine under consideration one of the strongest features showing the significance of exposure in the gradual retrogression from mesophytism to xero-

phytism was the paucity of tender mesophytic forms and the less luxuriant vegetation in general on the south-facing slopes. In the early spring the north-facing slopes of the ravine were covered more abundantly with the various plants of the vernal flora and certain mosses than the south-facing slopes.

Plants of the Ravine and the Oak Uplands

The plants of the ravine are recorded under two more or less distinct physiographic areas; the xeromesophytic slopes of the gullies (Region 1 of the table) and the mesophytic slopes of the ravine (Region 2). Some of the plants of the oak uplands (Region 3) are listed, to emphasize the differences between it and the ravine. The vegetation of the oak uplands may be thought of as either antedating or succeeding that of the ravine. The vegetation in these three successional regions is not entirely distinct, but even a superficial examination of the following list shows striking differences. As this study covers only the period from June 21 to October 18, 1913, much of the vernal vegetation is omitted.

In the examination of this list of plants it should be borne in mind that the vegetation of the slopes of the gullies and ravine is noted much more completely than that of the oak uplands; that the individuals of certain species were generally more numerous on the slopes of the ravine than on the slopes of the gullies; and that in certain localities of the ravine such plants as *Osmorhiza longistylis* (Pl. III, Fig. 5), *Amphicarpa monoica* (Pl. II, Fig. 4), and *Aralia nudicaulis* (Pl. IV, Fig. 6) had developed pure growths to the exclusion of all other species. Furthermore, and most important of all from the standpoint of this study, the list of plants for any of the three regions must not be considered as static but as dynamic in character. As already emphasized in an earlier part of this paper, with the changes in the physiography of the ravine the vegetation of its slopes tends to assume a xerophytic aspect, but only until stability of topography favors the succession of forest types, whose climax in the Evanston-Waukegan region is essentially the same as that of the mesophytic slopes of the ravine, the hard-maple type.

An investigation which is to determine whether or not the differences in the evaporative power of the air and in the soil-moisture content account for these successions and the minor differences within each of the areas where plants have been listed, involves, as the first step, the selection of certain typical stations—stations significant from the standpoint of exposure and ravine development; as the second step, the measurement, at regular intervals, of the evaporative power

Species	Region 1	Region 2	Region 3
[Trees and shrubs]			
Juniperus communis	×		
Sheperdia canadensis	×		
Thuja occidentalis	×		
Populus grandidentata	×		
Prunus serotina	×		
Salix glaucophylla	×		
Elæagnus argentea	×		
Ostrya virginiana	×		
Lonicera Sullivantii	×		
Tilia americana	×	×	
Ceanothus americana	×	×	
Acer saccharum		×	
Carpinus caroliniana		×	
Juniperus virginiana		×	
Fraxinus americana		×	
Hamamelis virginiana		×	
Viburnum Opulus		×	
Cornus alternifolia		×	
Cornus paniculata		×	
Cornus circinata		×	
Ribes Cynosbati		×	
Psedera quinquefolia		×	
Menispermum canadense		×	
Celastrus scandens	×	×	×
Rhus toxicodendron	×	×	×
Quercus alba			×
Quercus rubra			×
Quercus velutina			×
Quercus macrocarpa			×
Carya ovata			×
Corylus americana			×
[Herbaceous plants]			
Rudbeckia hirta	×		
Fragaria americana	×		
Melilotus alba	×		
Equisetum arvense	×		
Equisetum hyemale	×		
Pedicularis canadensis	×		
Echinocystis lobata	×		
Krigia amplexicaulis	×		
Saponaria officinalis	×		
Polygala Senega	×		
Aster lævis	×		
Aster multiflorus	×		
Gentiana quinquefolia	×		
Polytrichum commune	×		
Helianthus divaricatus	×		
Asclepias syriaca	×		
Desmodium rigidum	×		
Monarda fistulosa	×	×	×
Catherinea undulata		×	
Mnium sp.		×	
Anemonella thalictroides		×	×
Adiantum pedatum		×	
Botrychium virginianum		×	
Asclepias phytolaccoides		×	
Thalictrum dioicum		×	
Uvularia grandiflora		×	
Mitella diphylla		×	
Hepatica acutiloba		×	
Trillium declinatum		×	
Viola cucullata		×	
Galium triflorum		×	
Anemone virginiana		×	
Cryptotænia canadensis		×	
Osmorhiza longistylis		×	
Amphicarpa monoica		×	
Impatiens biflora		×	
Allium tricoccum		×	
Smilax herbacea		×	
Aralia nudicaulis		×	
Aralia racemosa		×	
Desmodium grandiflorum		×	
Polygonatum commutatum		×	
Sanicula marilandica		×	
Heracleum lanatum		×	
Solidago canadensis		×	
Convolvulus sepium		×	
Sanguinaria canadensis		×	
Helianthus hirsutus			×
Erigeron philadelphicus			×
Erigeron ramosus			×

of the air and the soil-moisture content at the stations selected; and finally, as the third and last step, the interpretation of results.

Location and Description of the Stations

In this study seventeen different stations were established; fifteen in the ravine, one in the oak uplands, station 16, and still another in the open uplands, station 17 (Pl. IX, Fig. 15), the vegetable garden of the McLeish estate. The fifteen stations in the ravine were located, speaking generally, as follows: Station 1 (Pl. I, Fig. 2) in an embryonic ravine; station 2, in a portion of a ravine, with lateral cutting delayed, forming a miniature clay cañon; stations 3 (Pl. I, Fig. 1), 4 (Pl. III, Fig. 5), 5 (Pl. IV, Fig. 6), 6 (Pl. V, Fig. 8), and 7 (Pl. VI, Fig. 9), in the part of the ravine with the mesophytic forest vegetation on the slopes; stations 8 (Pl. IV, Fig. 7), 9 (Pl. VII, Fig. 10), 10 (Pl. VII, Fig. 11), 11 (Pl. II, Fig. 4), and 12 (Pl. VIII, Fig. 12) in a portion slightly less mesophytic than the preceding; and stations 13 (Pl. VIII, Fig. 13), 14 (Pl. II, Fig. 3), and 15 (Pl. IX, Fig. 14), on the slopes of a wash or gully near the mouth of the ravine. The specific geographical location of each of these stations in the ravine and its tributaries and also of those in the oak and open uplands is shown on the surface map (Pl. XVIII), while the angle of slope, direction of exposure, and soil and vegetation characteristics are enumerated in the following tabular summary.

The "wilting coefficient"—a term used by Briggs and Shantz ('12:9) to represent the moisture content of a soil corresponding to the wilting point of a plant—for various soils in the McLeish ravine was correlated with the soil-moisture equivalent by an indirect method devised by these authors ('12:56–57). This coefficient indicates the limit of soil-water content above which growth must occur, although plants will live and continue to draw water below this point.

In listing the dominant vegetation of each station the emphasis was placed on the herbaceous forms and the seedlings of shrubs and trees because they are a much better index of present ecological conditions than the mature trees.

Measurement of the Evaporative Power of the Air

The instrument that was used to measure the evaporative power of the air in the different stations was the Livingston ('10) porous cup. The structure and operation of this simple instrument have been so well set forth by the inventor and others that have used it for scientific purposes that an explanation of its management would be

DESCRIPTIVE SUMMARY CONCERNING STATIONS

No. of station	Angle of slope	Location of slope	Exposure	General character of soil	"Wilting coefficient"	Dominant plants	Av. daily evap.
1	75°	Foot	W.	Sandy clay, mixed with pebbles. Powdery white	—	None	5.44 c.c.
2	80°	Near top	N.E.	Clay and humus, more clay than humus	15.2	Species of moss	3.27 c.c.
3	—	Foot	N.W.	Alluvium and humus, about 3 in. thick	17.9	*Acer saccharum* *Smilax herbacea* *Mitella diphylla*	4.75 c.c.
4	60°	Middle	N.W.	Black loam	18.3	*Osmorhiza longistylis*	4.28 c.c.
5	55°	Near top	N.W.	Black loam	16.4	*Aralia nudicaulis*	6.67 c.c.
6	60°	Middle	S.E.	Clay and loam	17.9	*Acer saccharum* *Fraxinus americana*	5.51 c.c.
7	—	Near top	S.E.	Principally humus	18.5	*Juniperus virginiana* *Quercus alba*	7.6 c.c.
8	Abrupt rise above sta.	Foot	N.	Soil matted by roots	21	No herbaceous vegetation	3.67 c.c.
9	65°	Middle	N.	Sandy clay mixed with pebbles	13.5	*Hepatica triloba*	6.36 c.c.
10	At foot of precipice	Near top	N.	Same as above	12.5	Mosses	6.0 c.c.
11	50°	Middle		Same as station 9	12.8	*Amphicarpa monoica*	5.74 c.c.
12	45°	Near top	S.	Same as station 9	12.7	None	7.93 cc.
13	—	Foot	N.W.	Sandy clay	10.3	*Equisetum arvense*	8.93 c.c.
14	Small plateau	Middle	N.W.	Sandy clay	11.4	*Aster* spp.	8.31 c.c.
15	Foot of vertical wall	Near top	N.W.	Sticky clay	13.1	None	9.32 c.c.
16	Level surface	Oak woods		Boulder clay with humus	20.4	*Helianthus hirsutus*	8.78 c.c.
17	Level surface	Strawberry bed		Good garden soil	16.4	Strawberry plants	16.39 c.c.

superfluous. The writer is aware that the instrument does not register with complete accuracy the evaporative power of the air when there has been precipitation during the period for which the measurement is made. During a rain, indeed, there may be a flow of water into the bottle. Drizzling rain for a long period will cause more water to enter the cup than will the same aggregate precipitation if due to a heavy rain extending over a short period. Since the results in this study have only a comparative value, the entrance of water into the bottles does not vitiate the results. This fact was first pointed out by Brown ('10) and later emphasized by Fuller ('11). In the handling of the instruments for scientific accuracy, in the selection of the intervals of time for reading, and in plotting the results, the writer had the constant advice and suggestion of Dr. Fuller, of the Department of Botany of the University of Chicago. Without his help many of the difficulties would not have been so readily overcome. All the instruments were standardized before being placed in the respective stations, and restandardized at intervals of six to eight weeks. By the coefficients thus obtained all the readings were reduced to a common unit. The first reading was made on July 5, 1913, and weekly readings were made thereafter until October 18, when the last record was made. Thus the investigation extended over a period of 112 days. Very few of the instruments were molested during the entire season, and hence the regularity of the results for each of the stations is rarely interrupted. These results are expressed as the average daily loss for the weekly interval between the readings. These results are graphically represented with the weekly intervals as abscissæ, and the amount of daily loss by the standard atmometer in cubic centimeters as ordinates.

INTERPRETATION AND DISCUSSION OF RESULTS

1. The graphs in Figure 16 (Pl. X) show that the average daily rate of evaporation for the weekly intervals was almost uniformly greater in the embryonic ravine than in either the narrow or broad portions, and greater in the broad than in the narrow. The average amounts of evaporation per day for the entire season at stations 1, 2, and 3 were 5.44 c.c., 3.27 c.c., and 4.75 c.c. respectively; that is 2.17 c.c. per day greater in the embryonic ravine than in the narrow portion, .69 c.c. greater in the embryonic ravine than in the broad portion, and 1.48 c.c. greater in the broad than in the narrow portion. In terms of percentage the rate of evaporation was 66.3% greater in the embryonic than in the narrow portion, 14.5% greater in the embryonic than in the broad, and 45.2% greater in the broad than

in the narrow.* Since all of these stations are located near the floor and represent successional stages in ravine development, the data suggest a movement from moderate moisture conditions in the embryonic ravine to greater moisture in the narrow portion, with a reversion to slightly drier conditions as the ravine changes from the V-shaped to the U-shaped type.

2. The graphs in Figure 17 (Pl. X) show that the rate of evaporation was only about two-thirds as great at the foot of the northwest-facing slope as near the top of the same slope, and that there was little difference in the rate of evaporation for the greater part of the season between the foot and the middle of this slope. The average amounts of evaporation per day at the foot, middle, and near the top of this slope were 4.75 c.c., 4.28 c.c., and 6.67 c.c. respectively. The graphs in Figure 22 (Pl. XIII) show similar results; the amount of evaporation per day was 2.33 c.c., or 63.4%, greater near the top than at the foot of the north-facing slope. The rate of evaporation at the middle of this slope was, for about the first two-thirds of the season, nearly the same as near the top. The graphs in Figure 19 (Pl. XI) show similar results for the opposing slope, the average amount of evaporation per day being 4.75 c.c., 5.51 c.c., and 7.6 c.c. respectively for the bottom, middle, and top of the southeast-facing slope—2.85 c.c., or 60%, greater near its top than at its foot. A similar series of stations in a less mesophytic portion of the ravine exhibit a similar set of conditions to those found in the more mesophytic portion. Here the rates of evaporation at the bottom, middle, and top of the north-facing slope (Pl. XIII, Fig. 22) were respectively 3.67 c.c., 6.36 c.c., and 6.0 c.c., while for the south-facing slope (Pl. XIV, Fig. 24) they were 3.67 c.c., 5.74 c.c., and 7.93 c.c.; that is, the average amount of evaporation per day was 4.26 c.c., or 11.6% greater near the top of the south-facing slope than at its foot. The graph for the daily rate of evaporation for weekly intervals at the middle of the southeast-facing slope (Pl. XI, Fig. 19) is diagrammatically between the graphs for the evaporation at the foot of the northwest- and near the top of the southeast-facing slopes, and likewise the graph for the rate of evaporation of the middle of the south-facing slope (Pl. XIV, Fig. 24) is between the graphs for the foot of the north- and near the top of the south-facing slopes. As already pointed out, the rates of evaporation for the middle of the northwest- and north-facing slopes (Pl. XVII, Fig. 17, and Pl. XIII, Fig. 22) were not intermediary between those at the foot and near the top of these slopes; the coincidences in the

*In the computation of the percentage rates the smaller of the two numbers is always used as the base.

rates of evaporation at the middle and foot of the northwest-facing slope (Fig. 17) during the early part of the season might be attributed to the fact that the instrument at the middle of the slope was almost surrounded by a dense growth of *Osmorhiza longistylis* (Pl. III, Fig. 5); and the slightly higher rate of evaporation at the middle than at the top of the north-facing slope during the latter part of the season (Pl. XIII, Fig. 22) might have been due to the unusual exposure of the middle of the slope compared with that at the top (Pl. VII, Figs. 10 and 11). Further, the differences in evaporation on different parts of the northwest- and north-facing slopes (Figs. 17 and 22), are less than on corresponding parts on the opposite slopes, and thus a station between two other stations would give less striking differences. In summary, the graphs in figures 17, 22, 19, and 24 show that as the northwest-, southeast-, and south-facing slopes are ascended there is a graded rise in the evaporative power of the air, the southeast- and south-facing slopes showing this more decidedly than the northwest- and north-facing slopes.

3. The graphs in Figure 18 (Pl. XI) show that the rate of evaporation was generally greater near the top of the southeast-facing slope than near the top of the opposite slope, the average amount per day for the entire series being nearly 1 c.c., or 13.9%, greater; the graphs in Figure 20 (Pl. XII) show that the rate of evaporation was almost uniformly greater at the middle of the southeast-facing slope than at the middle of the northwest-facing one, the average amount of evaporation per day being 1.23 c.c., or 28.7%, greater; the graphs in Figure 23 (Pl. XIII) show that the rate of evaporation for every weekly interval was greater near the top of the south-facing slope than near the top of the opposite north-facing one, being 1.93 c.c., or 32.1%, greater; while the graphs in Figure 25 (Pl. XIV) show results at variance with those in Figure 20 (Pl. XII)—a greater rate of evaporation at the middle of the north-facing slope than at the middle of the opposite south-facing one. This was undoubtedly due, as before suggested, to the unusual exposure of the middle of the north-facing slope, which was subject to less shade than any of the other stations in the immediate vicinity excepting the one near the floor of the ravine. The results shown by figures 18, 20, and 23 indicate a greater loss of water and consequently drier conditions on the southeast-facing slope than on the northwest-facing slope, and likewise greater loss of water and drier conditions on the south-facing slope than on the north-facing one. This difference in evaporation is undoubtedly due to the fact that the incident rays of the sun strike the southeast- and south-facing slopes more nearly at right angles, which means greater absorption and radiation of energy on the southeast-

and south-facing slopes than on the northwest- and north-facing slopes. Furthermore, this difference tends to explain the presence of tender mesophytic forms on the north-facing slopes of a ravine during the early part of spring, before the development of leaves on the trees, and their absence on the south-facing slopes.

4. The graphs in Figure 21 (Pl. XII) show that the rate of evaporation was greater throughout the season in the oak uplands than near the top of the northwest- and of the southeast-facing slopes, being 2.11 c.c., or 31.6%, greater per day for the entire season in the oak uplands than near the top of the northwest-facing slope, and 1.18 c.c., or 15.5%, greater than near the top of the southeast-facing slope. The graphs in Figure 26 (Pl. XV) show similarly that the rate of evaporation in the oak uplands was generally greater than near the top of the north- and south-facing slopes, the average daily evaporation for the entire period being 2.78 c.c., or 46.3%, greater in the oak uplands than near the top of the north-facing slope, and .85 c.c. per day, or about 10%, greater than near the top of the south-facing slope. This indicates that the upper portions of the south-facing ravine slopes have an evaporation very close to that of the oak uplands. Indeed one might expect a greater evaporation near the top of the south-facing slopes than in the oak uplands, due to the influence of slope exposure. Further, the differences in the average amount of evaporation per day between the oak uplands and near the floor of portions of the ravine were 4.03 c.c. and 5.11 c.c. In summary, all of the preceding statements show greater evaporation in the oak uplands than in any part of the mesophytic portion of the ravine. These differences may account for the more xerophytic aspect of the vegetation in the oak uplands than of that in the ravine (see p. 5). The graphs in Figure 21 (Pl. XII) and Figure 26 (Pl. XV) further show that the rate of evaporation in the open uplands, the strawberry bed, was nearly twice as great as in the oak uplands or in the most xerophytic portion of the ravine, the average daily rate for the entire period near the top of the northwest- southeast-, north-, and south-facing slopes, the oak uplands, and the open uplands being 6.67 c.c., 7.6 c.c., 6 c.c., 7.93 c.c., 8.78 c.c., and 16.39 c.c. respectively. The high rate of evaporation in open uplands clearly shows the effect of shade in retarding evaporation. This gives some conception of the relatively high rate of transpiration of the plants that constitute the various crops as compared with the vegetation that springs up in the forests, it having been clearly shown by Livingston ('10) that there is a definite relation between rate of evaporation of water from a free surface and the rate of transpiration in a leaf.

5. The graphs in Figure 27 (Pl. XV) show relatively high rates of evaporation when compared with the rates in other portions of the ravine. The average amounts of evaporation per day at the foot, middle, and head of the gully, or wash, were 8.93 c.c., 8.31 c.c., and 9.32 c.c. respectively. The evaporation on the gully slope shows less gradation than on the mesophytic slopes of the ravine, the difference between the average at the foot and the head of the gully being only .39 c.c. The evaporation on the gully slope was about the same as that in the oak uplands, which was 8.78 c.c. per day for the season. There is no question that during certain parts of the day the evaporation was greater on the gully slope than in the oak uplands. These high rates of evaporation on this slope suggest a vegetation with a xerophytic aspect (see p. 5). In the early part of the summer the gully slope was nearer devoid of vegetation than during the latter part of the season. Reference has been made in an earlier part of this paper to the luxuriance of the late-summer flora of the slope (Pl. II, Fig. 3). These changes in the vegetative conditions would tend to account for the special variations in the graphs for the gully slope, the presence of abundant vegetation about the atmometer tending to check the evaporation and its absence tending to increase the evaporation relatively.

6. A comparison of all the graphs, with the exception of those for the station in the open uplands and the stations on the gully slope, shows a remarkable similarity in the variation of the average daily loss for the weekly intervals, the minimum evaporation occurring during the week preceding August 16 and the maximum during the week preceding September 12. The graphs for the station in the open uplands and the stations on the gully slope show that the lowest rate of evaporation was during the same week as for the other stations, while the highest rate for the open uplands was during the week preceding August 2, and for the stations on the gully slope high rates occurred during the weeks preceding July 12 and 26, and August 2 and 31, as well as during the week preceding September 12.

SUMMARY AND CONCLUSION

The average daily evaporation rate for any weekly period was greater in the embryonic ravine than that for the corresponding weekly period in the narrow ravine; almost always greater in any portion of the broad ravine with mesophytic slopes than in the narrow ravine; greater near the top of slopes of mesophytic portions of ravine than near the floor; generally greater at the middle of the southeast-facing slopes than at the middle of the opposite slope; al-

most uniformly greater near the top of the southeast- and south-facing slopes than near the top of the opposite northwest- and north-facing slopes; usually greater in the oak uplands than in any mesophytic portion of the ravine; and, finally, the greatest average daily evaporation for any weekly period for any of the stations was in the open and exposed upland, as noted for the strawberry bed. (Pl. XVI, Fig. 28.)

If the differences in the evaporative power of the air at the different stations are taken as an index of the relative xerophytism and mesophytism of the vegetation, the preceding summary permits the following ranking of the stations, based upon their progressive xerophytism: the embryonic ravine, the narrow ravine, the foot of the mesophytic slopes, near the top of the northwest- and north-facing slopes, near the top of the southeast- and south-facing slopes, the oak uplands, and, the most xerophytic of all, the open uplands, represented by the strawberry bed. In general the movement is from a moderate rate of evaporation in the embryonic ravine to a lower rate in the narrow portion, and then a reversion to a higher rate, which gradually increases until it reaches its climax for the ravine near the top of the southeast- and south-facing slopes, and the climax for all of the stations in the open uplands.

The average amount of evaporation for each of the stations, as shown in Figure 28 (Pl. XVI), strongly reinforces diagrammatically the preceding conclusion.

The data clearly show that the differences in the rates of evaporation at the various stations are sufficient to indicate that the atmospheric conditions are effective factors in causing plant succession in a ravine.

Measurement of Soil Moisture

Samples of soil were taken weekly at depths of 7.5 cm. and 15 cm. in the narrow ravine, station 2; at the foot of the most mesophytic slope of the broad ravine, station 3; and at the foot of the gully slope, station 13. Each sample was placed in an air-tight soil jar and weighed when brought to the laboratory, and then placed in a drying oven at a temperature of 100° C. for one week, or until it ceased to lose weight. It was then weighed to determine the loss in weight resulting from the removal of the soil moisture, and the amount of such moisture was calculated in terms of percentage of the dry weight of the soil. The results have been plotted with the weekly intervals as abscissæ and the percentages of moisture as ordinates (Pl. XVI, Fig. 29, and Pl. XVII, Fig. 30 and 31).

It had long been thought that there could be no direct relation established between the percentage of water in a soil and the amount that is available for plant growth. Recently, however, a standard has been discovered by Briggs and Shantz ('12) by which the water content of the soil may be directly related to continuity of plant vitality. They have termed this standard or constant the "wilting coefficient" of the soil, and defined it (p. 6) as "The moisture content of the soil (expressed as a percentage of the dry weight) at the time when the leaves of the plant growing in that soil first undergo a permanent reduction in their moisture content as the result of a deficiency in the soil-moisture supply." Only the soil moisture over and above the wilting coefficient is available for plant growth, and hence this surplus has been termed "growth water." In this investigation the wilting coefficients of the various soils were found by the "indirect method" devised by Briggs and Shantz ('12: 56–57) which is based on the relationship of the wilting coefficient to the moisture equivalent as determined by physical methods. These coefficients have been represented (in figures 29, 30, and 31, plates XVI and XVII) by transverse broken lines, hence the growth water, or that portion of the soil moisture available for the growth of plants, is denoted by the interval between the lines representing the total percentage of moisture present and those showing the amount of the wilting coefficients.

Interpretation and discussion of results

1. The graphs in Figures 29 (Pl. XVI) and 30 (Pl. XVII) show that the percentage of moisture at stations 2 and 3 at a depth of 7.5 cm. was greater than at a depth of 25 cm. in each of the weekly examinations that was made. (The results are graphically represented, with the weekly intervals as abscissæ, and the percentages of soil moisture at the time of each examination as ordinates.) No such regularity in the per cent. of moisture content at the different depths was found at station 13 (Pl. XVII, Fig. 31).

2. The samples taken at a depth of 7.5 cm. show in a general way that the per cent. of moisture content in the narrow ravine at station 2 was less than in the broad ravine, station 3, and that the percentage of moisture content at the foot of the gully slope at station 13 was less than at either of the other two stations examined. The samples from a depth of 25 cm. did not show any such variations. From this we must not hastily conclude that conditions were more favorable for plant growth from the standpoint of soil moisture in the broad ravine than in the narrow ravine, or more favorable

at either of these two stations than at the foot of the gully slope, but further examine our data. What is really important in soil-moisture comparisons is the relative amount of growth water, or the difference between the actual water content of the soil and the water content not available for growth in the plant. The average percentages of moisture at a depth of 7.5 cm. for broad ravine, narrow ravine, and gully slope were, in the order named, 28.3, 24.1, and 17.7. The respective wilting coefficients for the same were 18, 15.1, and 10.2. This indicates that the average percentage of growth water in the broad ravine was 10.3, in the narrow ravine 9, and for the foot of the gully slope 7.5. Thus, from the standpoint of soil moisture, supplies were slightly more abundant in the broad than in the narrow ravine, and least abundant at the foot of the gully slope.

If the wilting coefficient may be regarded as indicating a condition in which the water supply of plants is reduced to such a degree as to cause permanent wilting, a recovery from which is only possible by an increase of the soil moisture, the graphs clearly show that at no time did the plants wilt permanently from the lack of water in the soil. One of the plants that wilted regularly during midday on sunshiny days was the jewel weed. This must not be attributed to the lack of water in the soil, but to a more rapid rate of evaporation from the portion of the plant above ground—a more rapid rate than that at which the water was taken in by the root of the plant. Such wilting would not be permanent wilting, which would eventually mean the death of the plant, but a temporary wilting, which would mean the restoration of the turgidity of the plant with a decrease of evaporation such as is caused by the coming of nightfall.

4. These data show in general so generous a supply of soil moisture at the various stations within the ravine that it may be safely assumed that the soil moisture is a factor contributing to the rapid advance of succession in such situations, and should have consideration in explaining the early attainment of advanced mesophytism.

5. These data also show that while the variations in soil moisture are not great at the different stations, the differences that do exist correspond in a general way to those of evaporation and may indicate a contributing factor in causing plant succession in a ravine. In order to make these soil-moisture studies more convincing, weekly examinations should have been made at the other fourteen stations.

Conclusion

The close relationship of evaporation and soil moisture to plant succession in a ravine is clearly evident from this study. It would have been more convincing if it had extended over a longer period;

but the writer does not believe that in case the period had been longer the general results would have been different, since the investigation extended over the most critical season of the year, namely, the part of the summer when the evaporation rates are relatively high and soil moisture relatively low; and these are the most critical conditions for the development and survival of plants.

Acknowledgments

Grateful acknowledgment is here extended to Dr. H. C. Cowles, of the University of Chicago, for suggesting the problem and site for study; to Mr. and Mrs. McLeish for their kindness in permitting weekly visits to their estate, on which the ravine is located; to H. DeForest for photographs of vegetation in vicinity of stations, and to Dr. Geo. D. Fuller, also of the University of Chicago, for his helpful suggestions in overcoming the difficulties that arose in the course of the investigation.

Literature cited

Atwood, Wallace W., and Goldthwait, James W.

'08. Physical geography of the Evanston-Waukegan region. Bull. 7, State Geol. Surv. Ill.

Briggs, L. J., and Shantz, B. L.

'12. The wilting coefficient for different plants and its indirect determination. Bull. No. 230, Bur. of Plant Industry, U. S. Dept. Agr.

Brown, Wm. H.

'10. Evaporation and plant habitats in Jamaica. Plant World, 13: 268–272.

Cowles, H. C.

'01. Plant societies of Chicago and vicinity. Bull. No. 2, Geogr. Soc. Chicago.

Fuller, Geo. D.

'11. Evaporation and plant succession. Bot. Gaz., 52: 193–208.

Livingston, B. E.

'01. Operation of the porous-cup atmometer. Plant World, 18: 111–119.

'13. The resistance offered by leaves to transpirational water loss. Plant World, 16: 1–33.

PLATE I

Fig. 1. Station 3, at the foot of the main ravine. Hard maple fallen across the channel as the result of lateral corrasion.

Fig. 2. Station 1, in an embryonic V-shaped ravine working its way back into the oak uplands.

PLATE II

Fig. 3. Station 14, in the gully. A miniature plateau showing a great variety and profusion of asters.

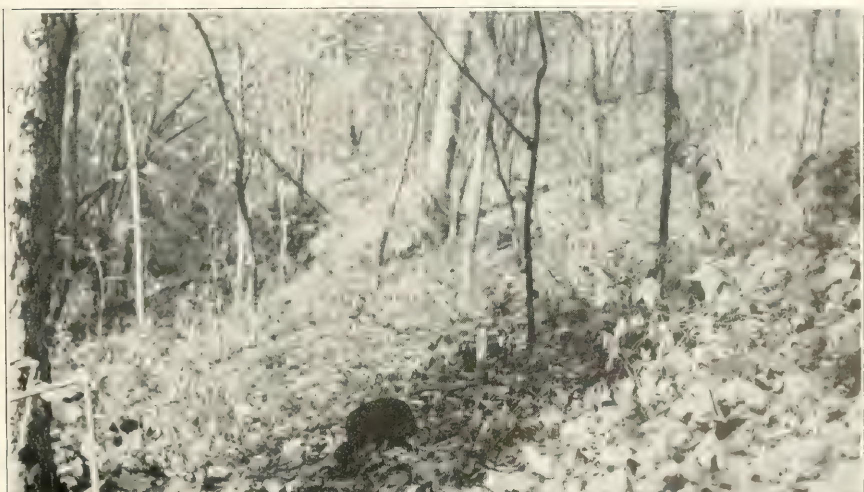


Fig. 4. Station 11, on the middle of the south facing slope covered with an almost pure stand of the hog peanut, *Amphicarpa monoica*.

Fig. 5. Station 4. The lower half of the picture shows an almost pure growth of *Osmorhiza longistylis*, on northwest-facing slope.

Plate IV

Fig. 6. Station 5, near the top of the northwest-facing slope. *Aralia nudicaulis* is the dominant plant of the undergrowth.

Fig. 7. Station 8, on the floor of the mesophytic portion of the ravine.

PLATE V

Fig. 8. Station 6, near the middle of the southeast-facing slope. Hard maple and ashes are dominant.

PLATE VI

Fig. 9. Station 7, near the top of the south-east facing slope.

Plate VII

Fig. 10. Station 9, on the middle of the north-facing slope. Species characteristic of the vernal flora are abundant here.

Fig. 11. Station 10, in the characteristic mesophytic forest of the ravine.

Plate VIII

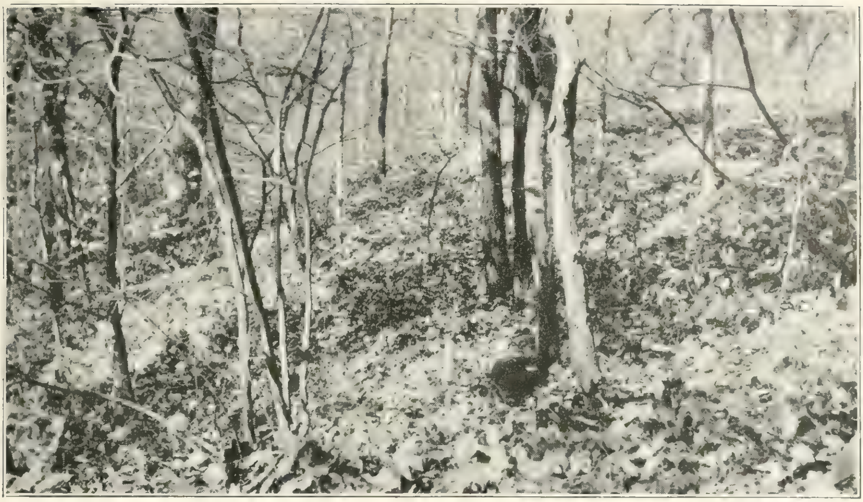


Fig. 12. Station 12, near the top of the south-facing slope among red oaks and witch hazel.

Fig. 13. Station 13, at the foot of the wash near the mouth of the ravine. The only place in the ravine showing *Juniperus communis*.

Plate IX

Fig. 14. Station 15, at the head of the wash near the mouth of the ravine.

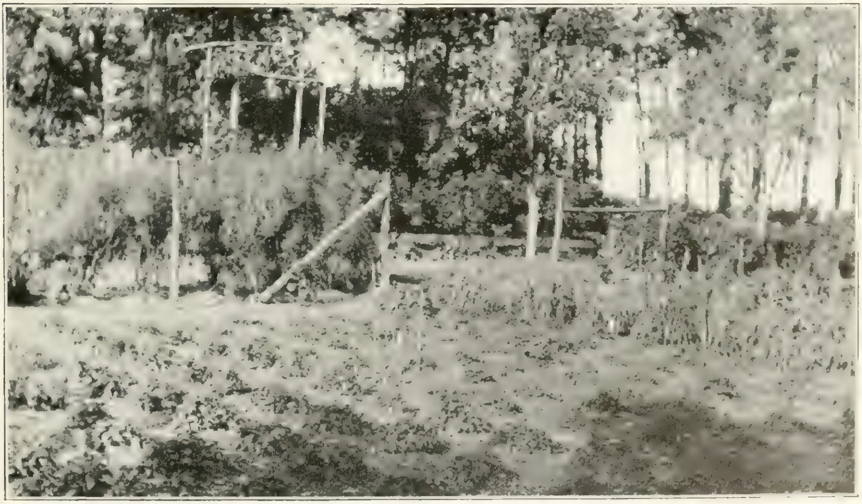


Fig. 15. Station 17, on the open upland. The strawberry bed on the McLeish estate.

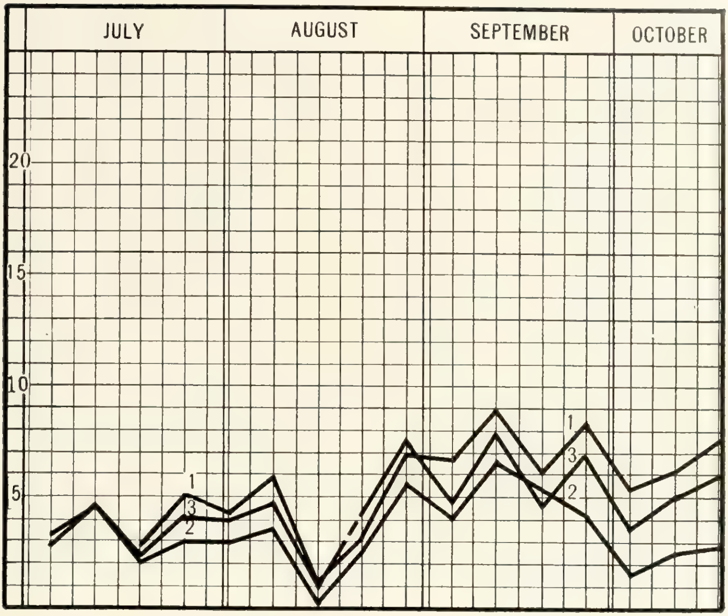


Fig. 16. Evaporation rates in an embryonic ravine (1), in a portion of ravine with lateral cutting delayed (2), and at the bottom of the most mesophytic portion of ravine (3). Stations 1, 2, and 3.

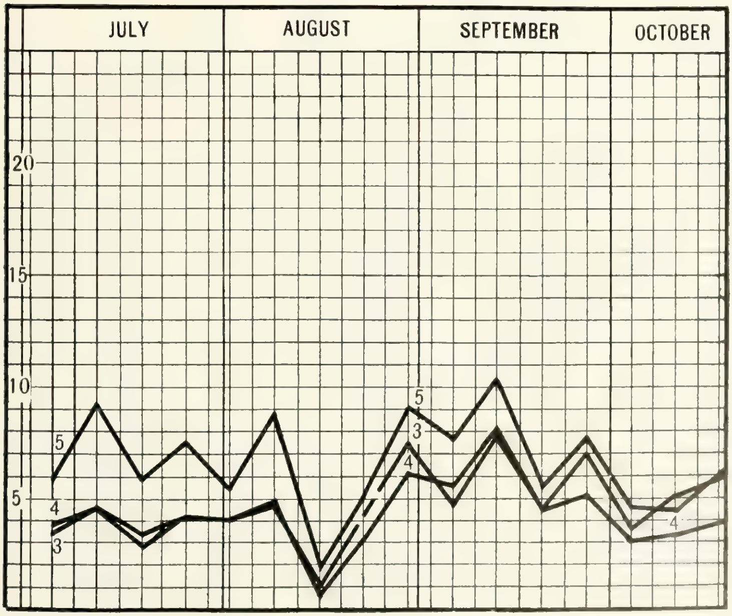


Fig. 17. Evaporation rates at the foot (3), middle (4), and top (5) of the north-west-facing slope of the most mesophytic portion of the ravine. Stations 3, 4, and 5.

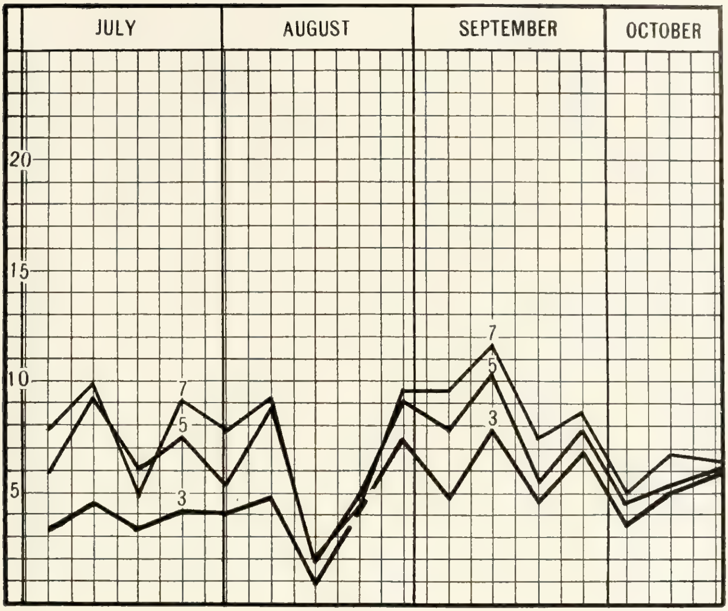


Fig. 18. Evaporation rates at bottom (3) and near the top of the northwest (5) and the southeast-facing (7) slopes of the ravine. Stations 3, 5, and 7

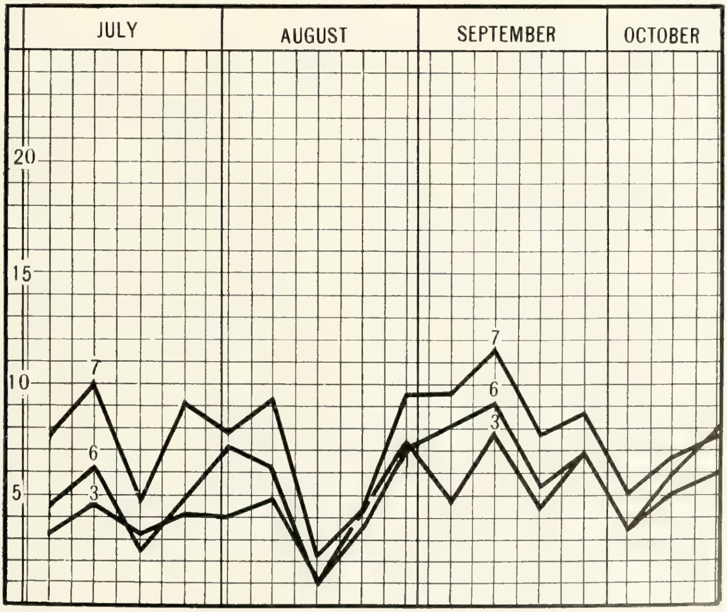


Fig. 19. Evaporation rates at foot of the northwest facing slope (3), and middle (6) and top (7) of the southeast-facing slope of the most mesophytic portion of the ravine. Stations 3, 6, and 7

Plate XII

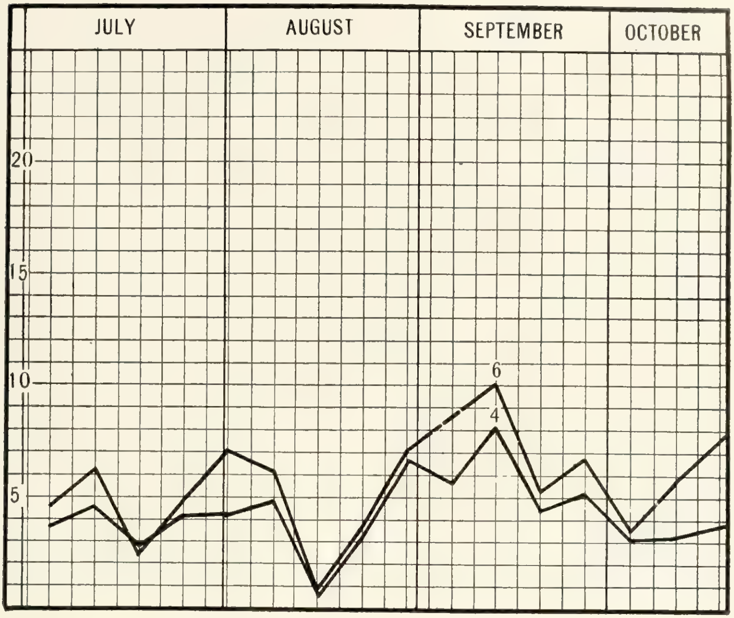


Fig. 20. Evaporation rates at the middle of both the northwest (4) and the southeast (6) facing slopes of the most mesophytic portion of the ravine. Stations 4 and 6.

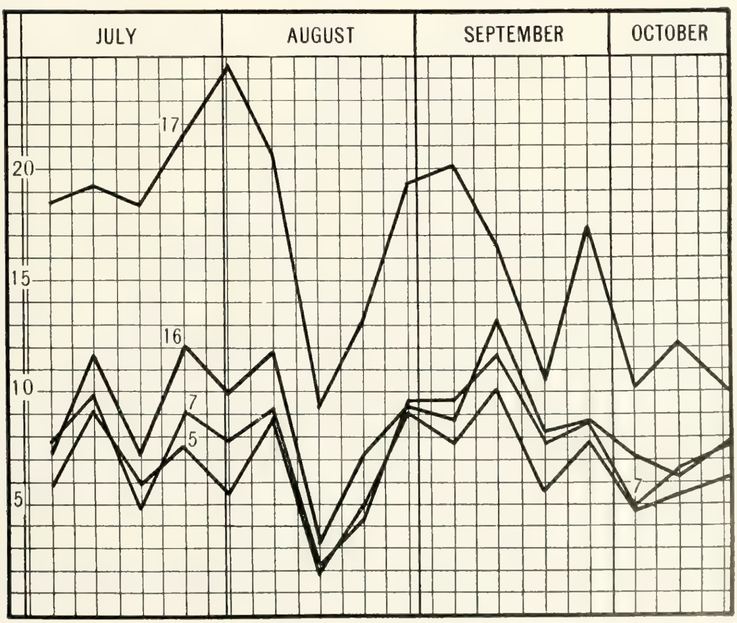


Fig. 21 Evaporation rates near the top of both northwest (5) and southeast (7) facing slopes of the ravine, the oak uplands (16), and the open uplands (17). Stations 5, 7, 16 and 17

PLATE XIII

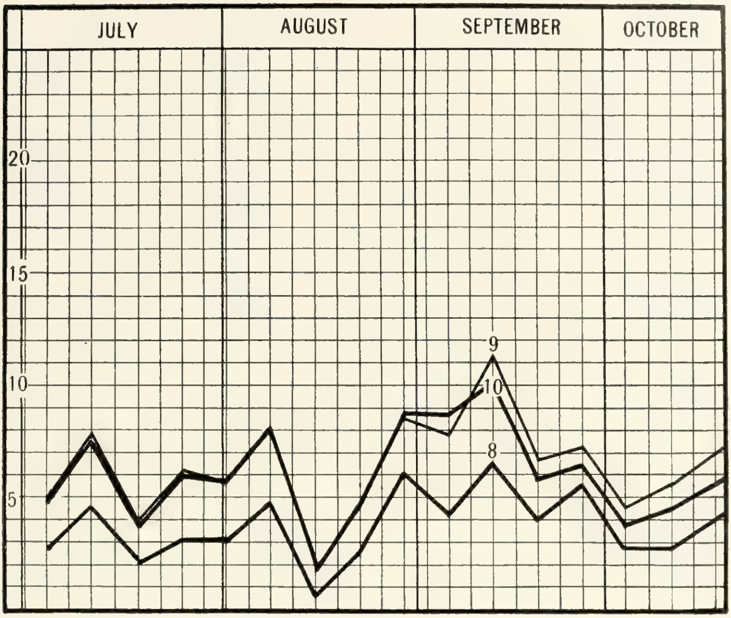


Fig. 22. Evaporation rates at the foot (8), middle (9), and near the top (10) of north-facing slope of ravine. Stations 8, 9, and 10.

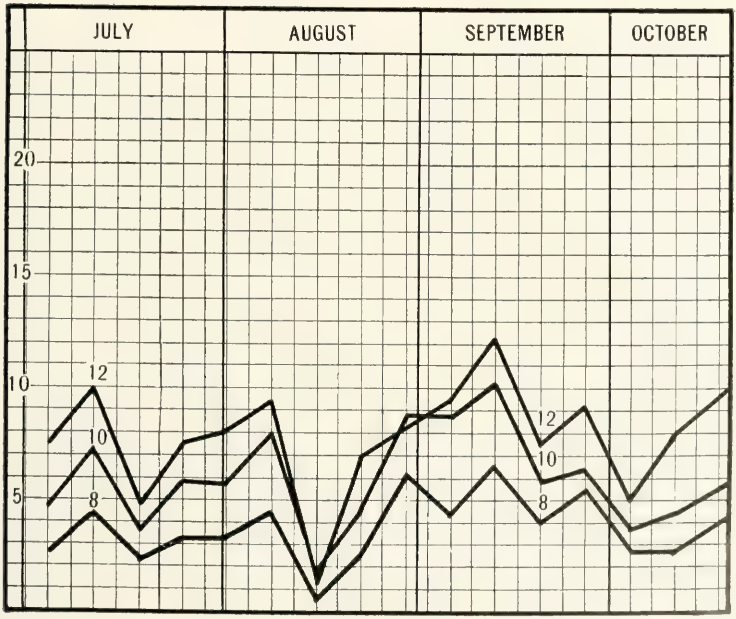


Fig. 23. Evaporation rates at the bottom (8) and near the top of the north (10) and of the south (12) facing slopes of the ravine. Stations 8, 10, and 12.

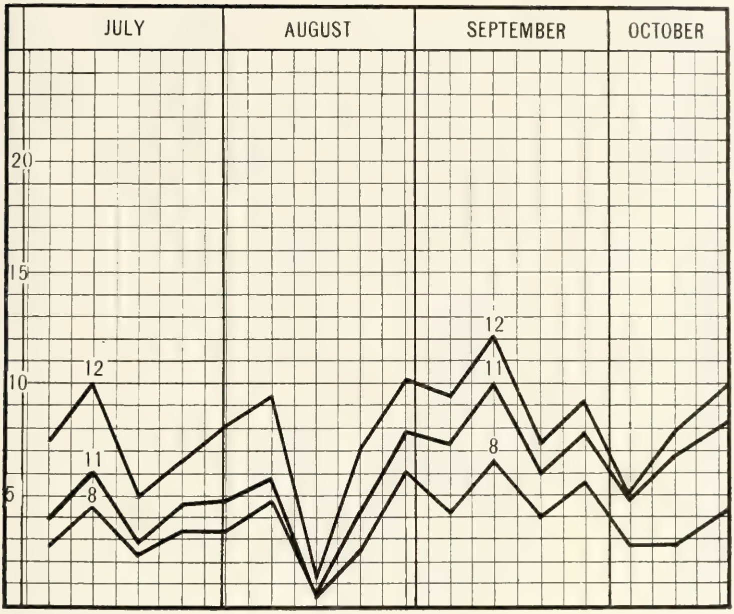


Fig. 24. Evaporation rates at the foot (8), at the middle (11), and near the top (12) of the south-facing slope. Stations 8, 11, and 12.

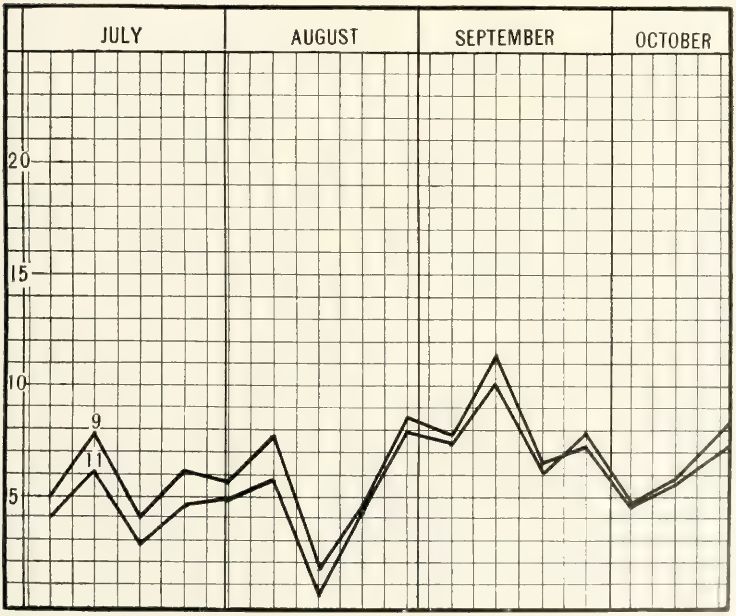


Fig. 25. Evaporation rates at the middle of both the north (9) and the south (11) facing slopes of the ravine. Stations 9 and 11.

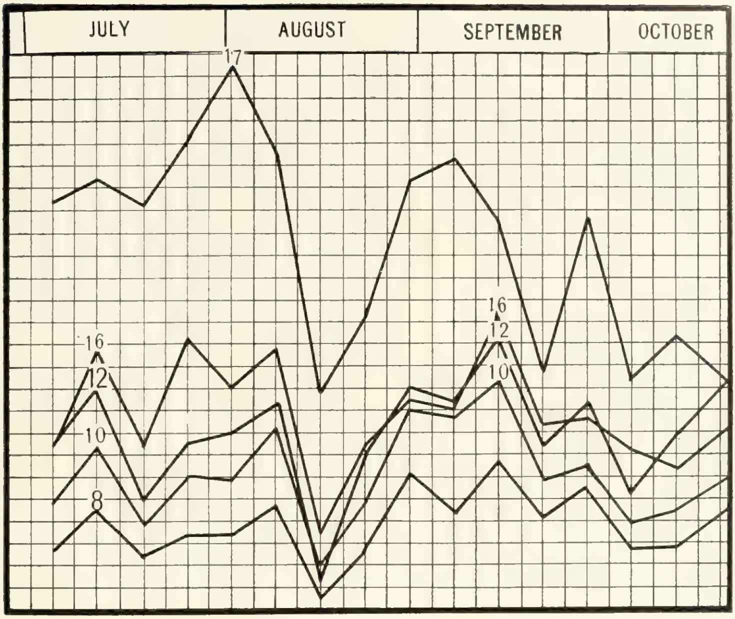


Fig. 26. Evaporation rates at the foot (8), near the top of the north (10) and of the south (12) facing slopes of the ravine, in the oak uplands (16), and in the open uplands (17). Stations 8, 10, 12, 16, and 17.

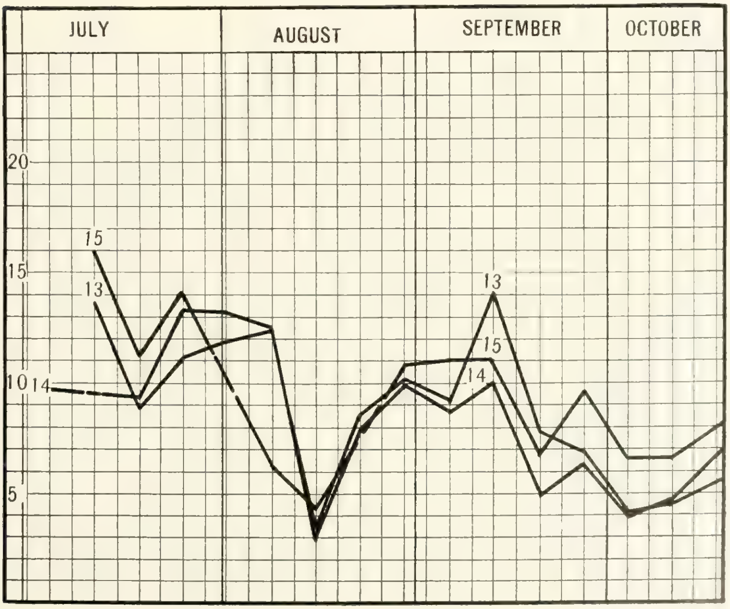


Fig. 27. Evaporation rates at the foot (13), middle (14), and top (15) of the wash or gully slope. Stations 13, 14, and 15.

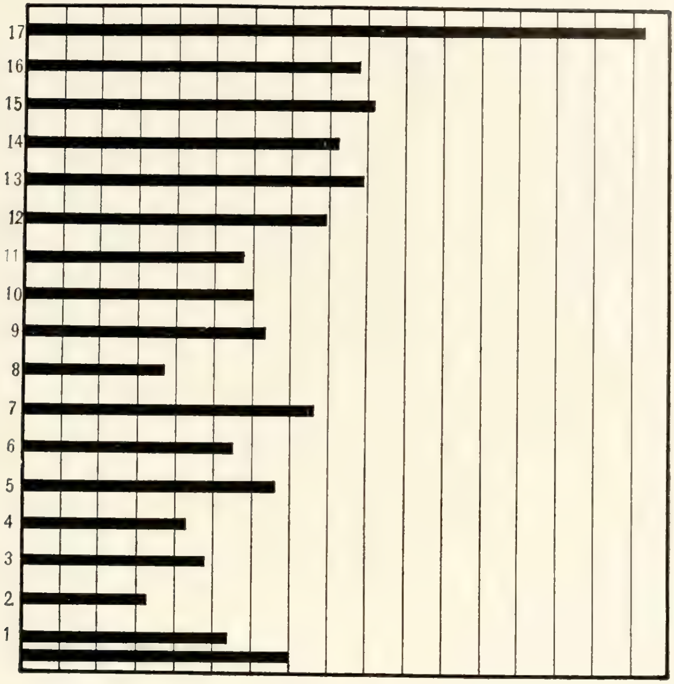


Fig. 28. Diagram showing the comparative evaporation rates at the different stations on the basis of the maximum average amount per day between July 5 and October 18, 1913.

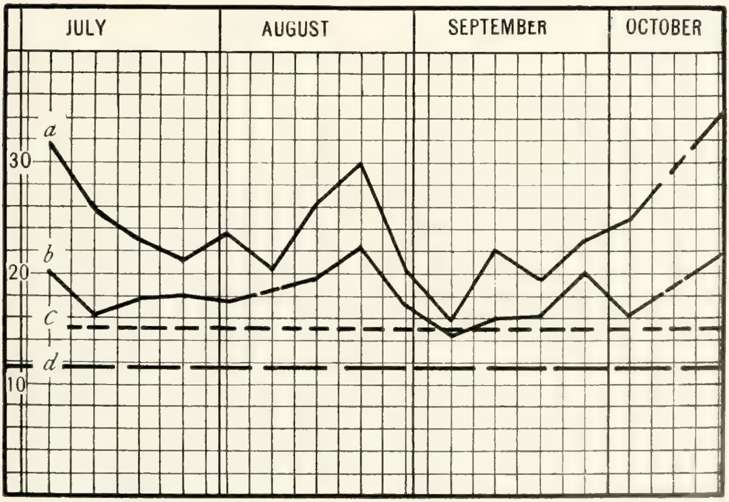


Fig 29. Graphs showing the range of soil moisture in the narrow ravine, Station 2, at depths of 7.5 cm. (a) and 15 cm. (b). Broken lines show the wilting coefficients for the soil at depths of 7.5 cm. (c) and 15 cm (d).

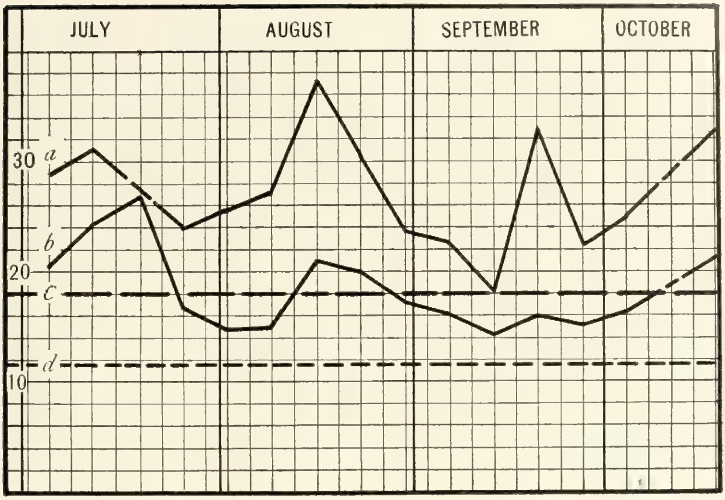


Fig. 30. Graphs showing the range of soil moisture at the bottom of the mesophytic ravine, Station 3, at depths of 7.5 cm. (a) and 15 cm. (b). Broken lines show the wilting coefficients for the soil at depths of 7.5 cm. (c) and 15 cm. (d).

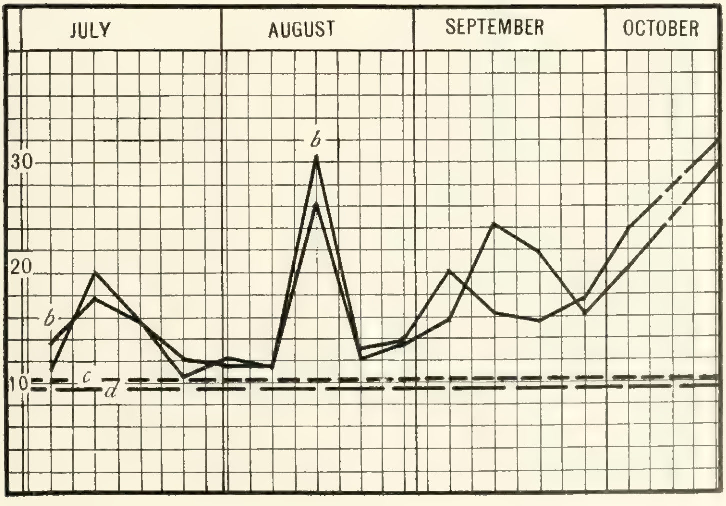
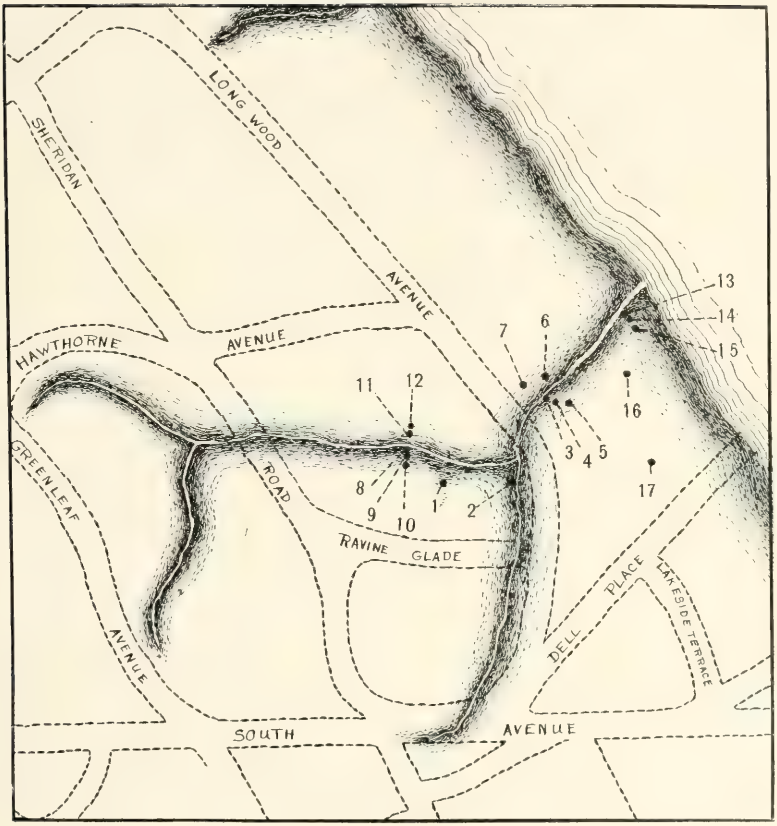


Fig. 31. Graphs showing the range of soil moisture at the foot of the wash, Station 13, at depths of 7.5 cm. (a) and 15 cm. (b). Broken lines show the wilting coefficients for the soil at depths of 7.5 cm. (c) and 15 cm. (d).

PLATE XVIII



Map of McLeish Ravine, Glencoe, Illinois. Scale about $\frac{2}{15}$ miles to the inch.

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. XII. MARCH, 1916 ARTICLE II.

A CLASSIFICATION OF THE LEPIDOPTERA BASED ON CHARACTERS OF THE PUPA

BY

EDNA MOSHER, PH.D.

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. XII. MARCH, 1916 ARTICLE II.

A CLASSIFICATION OF THE LEPIDOPTERA BASED ON CHARACTERS OF THE PUPA

BY

EDNA MOSHER, PH.D.

CONTENTS

ARTICLE II.—*A Classification of the Lepidoptera based on Characters of the Pupa.** BY EDNA MOSHER, PH.D.

INTRODUCTION

It is within comparatively recent times that the immature stages of insects have been considered of any taxonomic value. The economic entomologist early realized the value of being able to recognize the immature stages, for in many orders of insects the larval stages alone were responsible for many ravages upon crops and orchards. Still the matter was not taken up by the systematists, and the workers in the field of economic entomology contented themselves by rearing the adult to determine the species, and then describing, perhaps all the stages, or more probably the larval and adult stages as being those of economic importance. Nowadays we are beginning to see that it is impossible to construct an adequate classification of any group of insects unless we use every bit of information obtainable on their life history and habits.

It is possible to multiply instances of the value of the larval stages in classification, so that one scarcely needs to cite examples; but the pupae have been less frequently used. There are cases, however, in which the only good taxonomic characters available are found in the pupal stage of the insect. Such instances are found among the nematocerous Diptera, particularly in the family Chironomidae. Scudder ('89) was the first to attempt a classification of lepidopterous pupae, but his keys to the chrysalids were based, not on structural characters, but on the various projections from the body, the cuticular appendages, the coloration, and the mode of suspension.

Among the Lepidoptera a great deal of work has been done towards the classification of the larvae, but until 1893 nothing of importance had been done towards a study of the pupae. In this year Dr. T. A. Chapman, in a paper entitled "Some Neglected Points in the Pupae of Heterocerous Lepidoptera," called attention to the fact that the pupae possessed some remarkable taxonomic characters which might be used to clear up many of the disputed points in the classification

---

*Contribution from the Entomological Laboratories of the University of Illinois, No. 48.

of the order. This he endeavored to do for the groups in which material was available for study, and he has since published other articles as additional material was obtained. However, Dr. Chapman attempted no classification of the Lepidoptera on this basis, merely pointing out the pupal characters of the major groups and calling attention to instances in which a study of these characters would apparently alter the existing schemes of classification.

The attention of American entomologists was called to this subject by Dr. A. S. Packard ('95) in a paper entitled "Attempt at a New Classification of the Lepidoptera." He made a new grouping of the order based upon pupal characters and figured a large number of species. His determinations of the homology of the various parts of the pupae studied were far from correct, and this, of course, invalidated many of his conclusions.

Since that time nothing has been done in America towards a classification of the Lepidoptera based on pupal characters. The purpose of the present investigation is to present such a classification as far as material has been available for study. There is also an attempt to throw some light on the relationships existing between the different groups.

Changes Preceding Pupation

The person who begins the study of pupae with the preconceived notion that the pupal stage is an interpolated one in the insect's life and that a pupa bears little or no resemblance to either larva or adult, will probably find abundant cause for a change of mind before his study is completed. In the case of Lepidoptera one is apt to think that no similarities could possibly exist between any of the three stages of the insect's development after it leaves the egg. After careful study, however, one is surprised with the resemblance between the stages, for it is of the highest importance in the study of any group to be able to homologize larval, pupal, and imaginal characters. This has been done to some extent in certain orders of insects, particularly in those groups where the resemblance between the larva and adult is more striking than in the case of the Lepidoptera. Attempts have been made, however, even in this order, to homologize the mouth-parts of the larva and adult, and some of the larval structures have been homologized with certain structures in the pupa; but apparently the idea that all three stages should be studied has been left for other minds to entertain.

The first striking difference between larva and pupa is that of size. This difference is easily explained by the great difference in the size of the alimentary canal. Another striking difference is that the

pupa apparently lacks legs and prolegs. As will be shown later, the legs are always present, but folded and not in use, while the scars of all the prolegs remain to show their location and are very easily identified in the majority of cases. Many lepidopterous larvae possess striking tubercles and warts, and usually an abundance of setae. All larvae possess setae, but they are often inconspicuous. On the exposed portions of the body surface, in so far as observed, the pupa always retains the scars of these warts and tubercles, and the pupal body possesses setae arranged in most cases in the exact order in which they occurred in the larva. Many other structures of the larva can be easily identified in the pupa, and these will be discussed later.

In the case of insects with complete metamorphosis the name pupa is applied to the stage of the insect in which it is more or less quiescent while undergoing the changes which are necessary to fit it for its adult life. This word pupa, from the Latin meaning baby, was applied to this stage by Linnaeus from the resemblance of certain pupae to a baby which has been swathed or bound up, as was the custom in many parts of Europe at that time. This name was perhaps more appropriate for the pupae of the Lepidoptera than for those of any other order of insects because the appendages are usually all soldered to the thorax.

The change from larva to pupa in the Lepidoptera has been observed by many workers and is full of surprises for the amateur who wishes to breed these insects. The caterpillar when ready to pupate stops feeding, and in many instances leaves the food plant and wanders about, often apparently in the greatest of haste. Many are then seen on sidewalks, garden paths, and other traveled places, especially during the autumn months, when the majority of larvae are seeking a place to spend the winter. These larvae, if confined, will refuse food and many of them spin silk threads which are used to suspend the pupa or to form a cocoon. The alimentary canal is always freed of any food materials. The larval skin at this time loses its luster and becomes more and more wrinkled; and the body becomes shorter and shorter and appears swollen, which is due to the molting-fluid glands pouring their secretions between the outer and inner layers of cuticle. Some drops of a yellowish or reddish fluid are usually found in the place where larvae are confined and this, together with their peculiar appearance, often leads the amateur breeder of Lepidoptera to think that decomposition is taking place, and results in the hasty disposal of the now helpless insect. In the case of larvae which spin a cocoon these changes are not so easily observed, unless the cocoon is a very frail one, because most of the changes described take place inside of the cocoon. These changes may occupy but a few

hours, or may last for nearly a week. In the case of the common tomato-worm, *Protoparce carolina*, the transformation process usually requires five days; certain species of Papilio observed took but three days, but the time varies much with different individuals and the conditions under which they live.

When the molting fluid has done its work in loosening the larval cuticle, this splits along the meson of the thorax, and is gradually worked to the caudal end of the body, liberating the enclosed pupa. The liberated pupa is covered with a more or less transparent cuticle and resembles the pupa of the more generalized Neuroptera, Trichoptera, and Coleoptera. In all of these orders, the insects on casting their larval skins show the first resemblance to the adult insect. In the Neuroptera, Trichoptera, and Coleoptera, the appendages, as well as the body, are encased in a pupal skin, are free from each other and the body, and together with the body segments possess considerable freedom of motion. This does not mean that the pupae have any power of locomotion; on the contrary they are quite helpless, and for this reason are frequently—in common with the great majority of pupae—protected by some sort of a cocoon, or earthen cell. The lepidopterous genus Micropteryx, which is supposed by many to be the most generalized of its order, retains freedom of motion in all the appendages and in all but the fixed caudal segments of the abdomen. This freedom of motion is gradually lost in lepidopterous pupae as specialization advances, and the adult appendages are not fully developed when the pupal stage is assumed, although the cases of the appendages of the pupa are fully formed. Specialization in the pupa consists also in the hardening of the exposed parts of the cuticle through the deposition of chitin, and in the soldering of the appendages to each other and to the body of the pupa. In the generalized families the appendages are soldered to each other but often remain free from the body surface; later the wings become attached to the body surface, but any parts of the antennae, legs, or maxillae extending beyond their caudal margins remain free. The tips of these appendages are provided for in various ways in the higher families, but are always found soldered firmly to the surface of the body of the pupa. Proceeding hand in hand with the soldering down of the appendages is the loss of motion in the abdominal segments. Among certain families there is motion between all of the adjacent segments. There is, however, a successive loss of motion between segments, until the conjunctiva between all but two of the segments is inflexible in some forms, and even in some of the Lepidoptera, entire freedom of motion has been lost in all of the segments.

Among generalized forms where the appendages are soldered together, the cuticle of the exposed parts of the body contains but very little chitin, and is but slightly differentiated in texture from the cuticle of the hidden surfaces. When the imago emerges, or even before that time if the body is slightly pressed, the appendages separate very readily from each other, and are not torn upon the emergence of the insect, so that the pupal skin often remains complete except for the slit on the dorso-meson through which the imago emerged. A very different condition exists, however, among highly specialized forms. Here the exposed portions of cuticle become very hard and firm, while those which are not exposed are very thin and delicate and are almost entirely destroyed at the emergence of the imago. The outer covering, of course, being so firmly soldered together, remains in one piece and is apparently complete except for the slit through which the insect emerged. This has led many to think that this outer chitinized portion was the entire pupal skin and that it was a structure, analogous perhaps to an egg shell, in which the pupa had been enclosed.

Another remarkable difference between the generalized and the highly specialized Lepidoptera lies in the fact that in the latter the appendages are not fully formed when pupation takes place, but consist of the transparent cuticular coverings through which one or more slender tracheae may be seen. The duration of the pupal stage doubtless influences this, there being a stronger tendency among highly specialized forms to hibernate as pupae.

During the life of the pupa the adult parts are developing, and before it is time for the imago to emerge, the cuticular parts of the adult are fully formed. In the generalized families previously mentioned and in some specialized forms where the pupal cuticle remains more or less transparent, one is able to see a part of the development taking place, especially in the case of the appendages. The scales appear on the legs and wings and the color pattern may often be easily traced on the latter several days before the emergence of the insect. This stage of the insect, after the cuticular parts are fully formed, and while it still retains its pupal skin, has been designated as the preimago*. If the pupal skin is not already dark in color, it grows considerably darker in the last few days before the insect emerges, and one is thus able to determine when the preimago stage is reached.

*Packard applied the term subimago to the corresponding stage in certain Hymenoptera. This is an unfortunate use of the term as subimago had already been applied to the first winged stage of the Ephemeridae.

External Morphology

The most important work on pupal morphology has been done by E. B. Poulton and Dr. T. A. Chapman. Poulton ('91) in his paper on the "External Morphology of the Lepidopterous Pupa" discusses a few pupal structures but does not attempt to name all of the parts or to locate any of them. So far as known he was the first to point out that the pupal structures were more than cases for the imaginal structures and objected to the terms pterothecae, ophthalmothecae, etc., as applied to pupae. Believing that Poulton's theory is correct, such terms have not been used in this discussion, nor the terms wing cases, antennal cases, leg cases, etc., but these are spoken of simply as wings, antennae, maxillae, etc. Chapman's papers, already referred to, discuss very fully some of the structures and describe their exact location; but as they include only a few figures one is left very much in doubt as to the identity of many of the structures and their location. W. Hatchett Jackson ('91) published a very valuable paper on the "Morphology of the Lepidoptera" in which he discussed the external determination of sex in the pupa. A short discussion of the chrysalis was published by Dr. S. H. Scudder ('89), and some of the parts were named. In a paper previously cited, Dr. A. S. Packard ('95) gives many figures of pupae and names the parts, but his homologies are far from correct. It seems necessary, therefore, before proceeding further, to discuss the principal pupal structures and indicate their location by means of figures.

The homologies given in this paper were determined by a series of dissections of pupae in various stages of development, the preimago being found most valuable for this purpose. Pupae of nearly every family mentioned in this discussion have been studied in this way, beginning with the Micropterygoidea and extending through the Hepialoidea, Cossoidea, and other generalized families, including the Saturnioidea which are believed to be the most specialized of lepidopterous pupae. The change from larva to pupa has been watched in many species and the subsequent folding and soldering down of the appendages carefully noted. A large number of species have been bred and a study of the method of dehiscence, as shown by the pupal skin, has thrown considerable light on many instances where there was doubt as to the number of free abdominal segments, or where a suture was obscured by folds or other modifications of the integument.

The three regions of the body—head, thorax, and abdomen—are easily recognized, and each will be discussed in turn. There occur, on all of the regions of the body, in different families prominent pro-

jections and ridges of various types especially in the Papilionoidea. These projections have no morphological significance.

THE HEAD

The usual sclerites found in the head of generalized insects may be located in lepidopterous pupae. The sutures are distinct in generalized pupae, but are obliterated in the more specialized groups.

Vertex.—This is an area found on the dorsum of the head. It reaches its highest development in the Gracilarioidea, but is usually distinct in all generalized pupae. It is bounded cephalad by the Y-shaped epicranial suture (es), and may be seen in Figures 3, 25, 29, 33, 49, 53, and 56; v. This area was referred to by Chapman and Packard as the dorsal head-piece.

Front.—The front is the sclerite to which the antennae are attached. It is bounded by the epicranial suture on the dorsal surface, and on the ventral surface by the fronto-clypeal suture, which normally extends for a short distance caudad from the base of each antenna and then transversely to the median line. In some pupae where there is a "shoving back" of the head parts as in the Pyraustidae (Fig. 76) and Sphingidae, the front is located on the dorsum of the head. The fronto-clypeal suture is usually not distinct except in very generalized forms. The superfamily Gelechioidea, however, shows it very distinctly. It is indicated in Figures 1, 8, 26, 30, and 36; f. In generalized pupae the front bears two setae on each side of the meson which are often very conspicuous.

Genae.—These sclerites are distinctly bounded in Eriocraniidae and Hepialidae (Figs. 1 and 8, g). They are found laterad of the front and clypeus, and mesad of the glazed eye. The mandibles are always adjacent to the genae at their lateral margins.

Clypeus.—Remarkably few pupae have the clypeus definitely bounded. The suture between the clypeus and labrum is seldom present, although it is often indicated by a furrow. It is then impossible to determine accurately as to its presence, but it has been considered as if it were present. The boundaries of the clypeus are shown very distinctly in Figure 1, cl. In the Hepialidae (Fig. 8) there is no clypeo-labral suture present although all the other head sutures are distinct. The clypeus can usually be identified by the presence of the invaginations for the anterior arms of the tentorium, which are associated with its lateral margins. This sclerite often bears prominent setae, and in the pupae of species whose larvae are borers it has often a distinct cutting plate or ridge.

Tentorium.—The invaginations for the anterior arms of the tentorium are very distinct and are either small pores or slit-like openings. They are associated with the lateral margins of the clypeus and are distinct in most pupae (Figs. 1, 14, 19, 30; at).

Labrum.—The labrum is usually distinct along its lateral and distal margins, but seldom separated from the clypeus by a distinct suture. Like the clypeus it usually bears setae which are especially conspicuous in the Eriocraniidae (Figs. 1 and 2, lb). A peculiar development occurs in the Heliozelidae and some other families where the labrum extends caudad over the appendages (Fig. 50).

Pilifers.—This term is applied to the caudo-lateral projections of the labrum, which are so well developed in many Lepidoptera. They are very large in certain superfamilies, notably the Pyralidoidea and the Papilionoidea, and their presence is easily detected by the lobes which are adjacent to the caudo-lateral angles of the labrum and often approximate, or meet on the meson caudad of it, or are separated by a narrow piece of the labial palpi (Figs. 70, 72, 74, 76, 78, 79; pf). The mandibles figured by Scudder ('89, Vol. 3, Pl. 87, Fig. 25) are the pilifers. There are often well-developed pilifers present, however, when there are no external indications of their presence.

Mandibles.—The mandibles are always located adjacent to the caudo-lateral angles of the labrum. They are not functional except in the Micropterygoidea. In this superfamily, as shown in a pupa of the Eriocraniidae (Fig. 1, md), the mandibles are very large and used by the pupa to cut its way out of its cocoon and in working its way to the surface of the ground. In the Hepialidae (Fig. 8, md) and in some other families (Fig. 11, md) the mandibular area is definitely bounded. In still other families the area is distinctly elevated and usually rugose, as in the Eucleidae and Aegeriidae (Figs. 19 and 36, md). This type of mandibular area is observed in many of the Sphingidae. In the majority of pupae, however, the mandibles are represented by a smooth area situated in the position indicated above.

Eye-pieces.—These are situated laterad of the genae and mesad of the antennae. There are always two regions to be noted: a smooth mesal portion, sometimes only a narrow band but often a wider lunate piece, called the glazed eye-piece; and the larger lateral portion, the sculptured eye-piece. The latter is so called bcause it is always sculptured like the adjacent parts of the thorax. The sculpturing on the head is seldom like that found on the thorax and abdomen, but, strange to say, that on the sculptured eye-piece is always like that on the thorax, although the eye-piece is probably an extension of the vertex. On the dehiscence of most generalized pupae the eye-pieces are

separated from the face-parts and remain attached to the conjunctiva which joins the vertex to the prothorax (Fig. 43). In the specialized forms they remain attached to the face-parts. A peculiar modification is found in the Eucleoidea (Figs. 17, 19, 23; se, ge) in which the eye-pieces form movable flaps seemingly to protect and to cover the mesothoracic spiracles which lie underneath. The glazed eye-piece probably represents the pupal eye.

Antennae.—These are always attached to the front and extend laterad, curving to the ventral surface of the body mesad of the mesothoracic wings. They may always be identified without any trouble (Figs. 1, 8, 11, 15, 28; a). In pupae with broadly pectinate antennae, as the Saturniidae, the mesal portion is frequently elevated and has been referred to as the "stem of the flagellum" of the antennae.

Labial Palpi.—These appendages lie adjacent on the meson caudad of the labrum except in the Eriocraniidae (Fig. 1, lp). They are visible in the majority of pupae (Figs. 8, 15, 28, 45, 61). They are frequently overlaid and concealed by the maxillae at their proximal end as in Figures 61 and 67, lp. Often they are entirely concealed by the maxillae with the exception of a small V-shaped piece just caudad of the labrum (Fig. 72). This was thought by Scudder to be a special piece for covering the base of the tongue.

Maxillae.—Where labial palpi are visible they occupy a mesal position, caudad of the labrum, with the maxillae laterad of them. When they are invisible and apparently absent, the maxillae lie adjacent on the meson, often overlying and concealing the proximal ends of the labial palpi as mentioned above. The maxillae (Figs. 1, 8, 17, 24, 28; mx) vary greatly in length but are never entirely lacking or concealed in the pupa. They often extend beyond the caudal margin of the wings, being sometimes free and sometimes soldered to other appendages. The greatest development is found in certain of the Sphingidae where the maxillae do not extend beyond the caudal margin of the wings, but the extra length is taken up in a loop at the proximal end which forms the so-called "jug handle" of Sphinx pupae. The maxillae are always measured on the meson from the caudal margin of the labrum to their distal end and are usually compared in length with the wings, which are measured from the caudal margin of the labrum to their caudal margin on the meson.

Maxillary Palpi.—Each palpus is represented on each side by a subrectangular or triangular area caudad of the eye-pieces and lying along the cephalic margins of the prothoracic and mesothoracic legs, frequently reaching as far mesad as the proximo-lateral angle of each maxilla. The normal position of these appendages is discussed under

the family Eriocraniidae and shown in part in Figure 1, mp. They may also be seen in Figures 28, 30, 32, 36, 38; mp. Structures which may be maxillary palpi are found in the genus Gracilaria (Fig. 47). The peculiar extensions of the maxillae in the Cossoidea and Eucleoidea are not considered as maxillary palpi (Figs. 15, 19, 23).

THE THORAX

The three segments of the thorax are always distinct. They are only visible on the dorsum, because the ventral and lateral surfaces are covered by the appendages.

Prothorax.—This segment probably varies more in size and shape than any of the others. There are some forms, as in the Gracilarioidea, Yponomeutoidea, and others, where the prothorax is very short on the meson (Figs. 53, 56, 58; p) or even invisible (Fig. 54), but is very wide at each lateral margin. It is longer in the Galleridae and certain families of Noctuoidea than in any other pupae examined.

Prothoracic Legs.—These lie adjacent to the maxillae at their proximal end. The coxae are frequently exposed, especially in generalized pupae where the appendages are free (Figs. 1, 11, 19; cx1), and dissection frequently showed a segment cephalad of the coxa, the trochantin, although there was no distinct suture indicated on the exterior, this being covered by the mouth-parts. The trochanter is a very small segment usually found at the caudal end of the femur when the leg is folded and is therefore generally concealed by the tibia and tarsus. The femur extends from the trochanter cephalad to the caudal margin of the head. It is frequently concealed by the tibia and tarsus which are the only portions of the prothoracic leg always visible, but they are often shoved slightly laterad so that a portion of the femur is exposed (Figs. 1, 8, 24, 32, 36; f1). The tibia and tarsus are seldom divided by a suture except in generalized pupae, where all the segments, even of the tarsi, are readily distinguished (Fig. 1, l_1).

Mesothorax.—The mesothorax is usually considerably longer than the other segments in specialized forms, but in generalized pupae all the segments are more nearly equal.

Mesothoracic Spiracle.—This is usually located on the dorsum between the prothorax and mesothorax, sunk deep in the conjunctiva between the segments with an opening adjacent to the caudo-lateral angles of the prothorax. Its primitive position appears to have been much farther ventrad (Fig. 2, msp) and it is found in this position in the specialized Trichoptera. It retains this primitive position in the superfamily Eucleoidea and in the family Nepticulidae. The caudal margin possesses curious modifications in different families in

the way of elevated ridges, tubercles, setae, etc., and in some of the Papilionoidea, particularly in the families Hesperiidae and Lycaenidae, there seems to be a definite external closing apparatus in many of the genera. Sometimes there is a tuft of setae; in others, a plug or plate of somewhat honeycombed appearance.

Mesothoracic Legs.—These are folded in exactly the same manner as the prothoracic legs and the femora are very seldom exposed, but may be seen in Figure 1, f2. The coxae are frequently visible (Figs. 1 and 48, cx2). The mesothoracic legs are usually longer than those of the prothorax. The tibia and tarsus of each leg are always exposed (Figs. 1, 8, 23, 30; l_2). They lie on the venter, between the prothoracic legs and the antennae.

Mesothoracic Wings.—The wings of the mesothorax almost conceal those of the metathorax, except in the most generalized forms where the appendages are free. In most families they are the only wings visible on the ventral surface (Figs. 1, 8, 36, 41; w1).

Tegulae.—The tegulae are the large lobes which, in the adult, cover the proximal end of the wing. They do not form separate pupal pieces but are indicated in some pupae (Fig. 2, t). The tegulae are referred to by many authors as the patagia. The patagia are lobes of the pronotum which project over the mesonotum.

Alar Furrows.—The furrows along each lateral margin of the mesonotum are designated as the alar furrows. They are best developed in the Aegerioidea (Fig. 37, af) although there are distinct depressions in many families.

Axillary Tubercles.—In the genera Tropaea and Telea of the Saturniidae, there is found a large tubercle at the base of each wing, with sometimes an additional smaller one. The edges of these tubercles are strongly chitinized and somewhat roughened, and serve to cut the cocoon for the emergence of the moth. They are probably assisted in this by the peculiar development of the wing sclerites of the preimago, which protrude into these tubercles and are sometimes found to have cut the pupal skin at the apex of the tubercle.

Metathorax.—This segment is longest in generalized forms, where its length is nearly equal to that of the mesothorax.

Metathoracic Legs.—The tibiae and tarsi of the metathoracic legs are never normally exposed for their entire length but are concealed by the other appendages excepting at their distal end. Only a small portion is visible in specialized pupae, and the appendages are often wholly concealed (Figs. 2, 8, 36, 45; l_3).

Metathoracic Wings.—These are usually covered by the mesothoracic wings except for a narrow strip along their dorsal margin.

In a few families a narrow strip of the metathoracic wings is visible on the ventral surface caudad of the mesothoracic wings (Figs. 1, 8, 19; w2).

THE ABDOMEN

The abdomen consists of ten segments, of which three, segments 8–10, are always "fixed"; that is, they possess no power of independent motion. In the generalized forms motion is possible between all of the other segments. A segment is said to be movable when there is movement between its caudal margin and the segment caudad of it. In many pupae the movable segments are capable of being telescoped so that only their caudal margins are visible. When the cephalic margin of a movable segment is referred to, it includes the rounded part of the segment which is covered by the transverse conjunctiva when the segments are retracted, or telescoped.

Proleg Scars.—The scars of the larval prolegs are found on the ventral surface near the meson (Fig. 11, psc) and are often conspicuous.

Tubercle Scars.—Those families in which the larvae have prominent tubercles show very definite scars in the pupae. These are especially noticeable in the Saturniidae.

Setae.—There are usually setae present on the abdomen, and they are arranged much as are those of the larvae. They are often very inconspicuous, otherwise they might furnish good taxonomic characters. There is often a dense covering of secondary setae over the entire surface, as in some gelechiids and lasiocampids. The Pterophoridae retain a spiny armature similar to that found in the larvae.

Spines.—These are found covering the dorsum of the abdomen in generalized pupae (Fig. 49), and larger ones are also found at the caudal end of the body (Figs. 27, 31). They are arranged in rows on the segments in Tineoidea and Tortricoidea (Figs. 27, 31, 39, 41).

Flanged Plates.—The flanged plates are best developed in the pupae of borers, but are found in other pupae as well. Figure 9 shows them well developed on the dorsum and also shows a well-developed ventral plate on the seventh segment. They are usually developed along the cephalic margin of the segment and prevent the telescoping of the segments.

Genital Openings.—In the male the genital opening is situated on the ventro-meson of the ninth abdominal segment. It is usually either a mere slit-like opening as in Figure 5, without any adjacent elevations, or it has a distinctly elevated tubercle on each side as in Figure 8, go, and occasionally is situated in a slight depression. In the females there are two openings which may or may not become con-

fluent. These may be mere rounded pores or slit-like openings, and are associated apparently with the eighth and ninth segments. The boundary lines between segments 8 and 9, and 9 and 10 are rarely distinct on the meson, and where they are distinct it seems as if the caudal opening were associated with the tenth segment. In the more specialized pupae the caudal margins of the eighth and ninth segments are more strongly curved cephalad near the meson than in the male (Figs. 34 and 44, go) and the segments are dovetailed together. The presence of the two openings apparently represents the more generalized condition (Figs. 7, 17, 28; go). They are confluent in *Podosesia syringae* (Fig. 36) and *Archips argyrospila* (Fig. 44).

Anal Opening.—This is always situated on the meson near the caudal margin of the tenth segment. It sometimes shows as a circular opening (Fig. 7, ao) but is usually slit-like (Figs. 8, 14, 17). It is usually surrounded on each side with several prominent wrinkles or folds.

Anal Rise.—The anal opening is frequently situated on the summit of a mound-like elevation known as the anal rise. The setae on this rise are very conspicuous in certain families of Tortricoidea (Fig. 38, ar).

Abdominal Spiracles.—Spiracles are always present on abdominal segments 1–8. The spiracles of the first segment are covered, so far as observed, by the wings, except in the superfamily Eucleoidea and the family Nepticulidae. The spiracles of the eighth segment are never functional and show no distinct opening.

Spiracular Furrows.—On the cephalic margin of the movable segments cephalad of the spiracles are found furrows which frequently extend almost to the meson on both dorsal and ventral aspects. They occur in several families, as the Liparidae and Geometridae, but are best developed in the Sphingidae, where they are lacking in but a few genera. They are usually separated by sharply carinate ridges and are of various types, but their function is unknown.

Cremaster.—The cremaster is a prolongation of the tenth segment and is not found in the more generalized pupae. It was homologized by C. V. Riley with the suranal plate of the larva. It is of various lengths and shapes and often bears setae at the distal end. Two types of cremaster are shown in Figures 41 and 65, cr. Its length is measured on the ventral surface from its junction with the curve of the ventral surface of the body, as in Figure 44, where ab represents the cremastral length.

Classification

As no extensive classification of the Lepidoptera based on pupal characters has been attempted hitherto, little has been done to determine what characters are of value in defining superfamilies, families, and genera. It has been necessary, therefore, to base specific, generic, and other distinctions on those characters found in such material as could be secured. The present investigation has been limited by the difficulty in obtaining representatives of many groups, and it is not expected that the tables and descriptions given will do more than furnish a basis for later work upon the subject. It is hoped, however, that they will call the attention of entomologists to the vast possibilities opened up by the use of the taxonomic characters available in pupae, and that further studies of the different groups will make it possible to identify an insect in one more stage of its life cycle—which can not fail to be of importance in the case of our economic species.

Analytical Table of Superfamilies

a. Mandibles present, large, functional, decussating, and extending beyond the lateral margins of the body. MICROPTERYGOIDEA.

aa. Mandibles, if present, never large, parallel or subparallel, and usually represented by small elevated tubercles.

b. Movable abdominal segments present cephalad of the fourth, or if no segments are movable cephalad of the fourth then the appendages free from each other and never soldered to the body wall, and the vertex longer than the prothorax measured on the meson.

c. True maxillary palpi never present, but sometimes lateral extensions of the maxillae (Figs. 15 and 19).

d. Body heavily chitinized and bearing transverse rows of spines or setae on the abdominal segments; spiracles never visible on the first abdominal segment.

e. Mesothorax never more than twice the length of the metathorax; seventh abdominal segment with a large flanged plate on the ventral surface; antennae filiform, short, only reaching caudad to the proximal end of the mesothoracic legs; head sutures all present except the clypeo-labral. HEPIALOIDEA.

ee. Mesothorax always more than twice the length of the metathorax; seventh abdominal segment never with a large

flanged plate on the ventral surface; antennae, if present, pectinate and reaching farther caudad than the proximal end of the mesothoracic legs; none of the head sutures distinct for the whole length. COSSOIDEA.

dd. Body never heavily chitinized, and never bearing the spines or setae on the abdominal segments in rows; spiracles always visible on the first abdominal segment.

EUCLEOIDEA.

cc. True maxillary palpi usually present; if absent, then the appendages free from each other, or the vertex longer than the prothorax on the meson, or the body possessing a distinct cremaster.

d. Dorsum of abdomen with a covering of small spines, usually over the entire length of the segment and not arranged in distinct rows; if spines are arranged in rows then the maxillary palpi are absent; vertex always longer than the prothorax on the meson. GRACILARIOIDEA.

dd. Dorsum of the abdomen with a distinct row of spines along the cephalic margin of the segment, with or without a caudal row; spines seldom found elsewhere on the segment but, if present, then the maxillary palpi present and well developed.

e. Caudal row of spines never present on the dorsum of the abdominal segments; maxillary palpi always present.

TINEOIDEA

ee. Caudal row of spines always present on the dorsum of the abdominal segments; maxillary palpi usually present.

f. Distinct cremaster never present; setae never present on the anal rise; wings narrow and pointed; large spines always present on the venter of the tenth abdominal segment. AEGERIOIDEA.

ff. Distinct cremaster usually present, if not, then setae present on the anal rise; wings broad and never pointed; large spines never present on the venter of the tenth abdominal segment. TORTRICOIDEA.

bb. Movable abdominal segments never present cephalad of the fourth; appendages never free from each other and usually soldered to the body wall.

c. Lobes indicating the presence of pilifers always present except in Gallerinae (Fig. 69) and Oeneinae (Fig. 80).

d. Maxillary palpi usually present, if absent, then abdominal segment seven is movable in the male, the body covered with a spiny armature, and both prothoracic and mesothoracic legs extending cephalad between the eye-pieces and the antennae, the former reaching nearly to the cephalic margin of the glazed eye, or a deep furrow lined with setae present on the dorsum between the ninth and tenth abdominal segments; antennae never clubbed at the distal end; femora of the prothoracic legs usually visible; labial palpi very seldom visible except as a small triangular or polygonal area caudad of the labrum and between the pilifers. PYRALIDOIDEA.

dd. Maxillary palpi never present; antennae always clubbed at the distal end; femora of the prothoracic legs never visible; a deep furrow lined with setae never present on the dorsum between the ninth and tenth abdominal segments; labial palpi never visible except as small triangular or polygonal areas caudad of the labrum between the pilifers and often entirely concealed. PAPILIONOIDEA.

cc. Lobes indicating the presence of pilifers never present.

d. Mesothoracic wings on the ventral surface at meson usually extending considerably beyond the caudal margin of the fourth abdominal segment, if not, then the body depressed, mostly in the thoracic region, the incisions between the movable segments very deep on the dorsum and venter and less deep at the lateral margins, and the caudal part of the antennae always adjacent on the meson for a considerable distance; abdominal segments 1–4 usually longer than the other segments; epicranial suture always present.

e. Maxillary and labial palpi present and well developed and a large portion of the prothoracic femora always exposed; if maxillary palpi are not present then the fronto-clypeal suture never visible; prothorax distinctly shorter on the meson than at each side, so that each half is triangular in outline; appendages soldered to each other but not to the body wall; fronto-clypeal suture never visible; antennae with the caudal portion very rarely touching and not moniliform in appearance. YPONOMEUTOIDEA.

ee. Maxillary palpi usually present, but labial palpi and prothoracic femora seldom visible, if visible, then the fronto-clypeal suture distinct; prothorax usually the same length

on the meson as at each side so that each half is subquadrangular in outline; appendages usually soldered firmly to each other and to the body wall; body usually ovate in outline, broadest in the thoracic region and usually strongly depressed; fronto-clypeal suture usually visible; antennae usually moniliform in appearance, the caudal portion always adjacent on the meson, usually for some distance; if only touching, then the fronto-clypeal suture is distinct.

GELECHIOIDEA.

dd. Mesothoracic wings on the ventral surface of the body at meson rarely extending beyond the caudal margin of the fourth abdominal segment, if beyond, then maxillary palpi never present; abdominal segments 1–4 or 1–6 rarely longer than the other segments; epicranial suture seldom visible.

e. Labial palpi usually present and well developed and from one fourth to one fifth the length of the wings, if not visible then the body usually shaped as in Figure 104; the abdomen with setae arranged around the scars of larval verrucae, and usually flanged plates on the abdomen and a cremaster present; or with a more or less dense covering of setae never arranged around larval verrucae, the body never of the shape in Figure 104 and flanged plates never present on the abdomen nor a distinct cremaster.

f. Labial palpi usually present and well developed and the prothoracic femora usually exposed, or if not, then both prothoracic and mesothoracic legs reaching cephalad to the eye-pieces; if both labial palpi and prothoracic femora are wanting then the body of the type in Figure 104; the abdomen with setae arranged around the scars of larval verrucae, flanged plates usually present on the abdominal segments and a distinct cremaster often present; body never with a more or less dense covering of setae, except arranged as mentioned above; maxillary palpi occasionally present.

NOCTUOIDEA.

ff. Labial palpi sometimes present, body never with a cremaster and always with a more or less dense covering of setae which are never arranged around larval verrucae; prothoracic femora never exposed; maxillary palpi never present.

BOMBYCOIDEA.

ee. Labial palpi never visible, unless represented by small triangular or polygonal areas caudad of the labrum; body very seldom with visible setae.

f. Suture adjacent to the proximal ends of the antennae and separating the clypeus and front always present and very distinct; antennae never broadly pectinate so that the width is one fifth of the length; spiracular furrows often present.

g. Antennae usually considerably broader near the proximal end, their greatest width usually greater than that of the prothoracic legs; antennae usually more than three fourths the length of the wings, if not, then the epicranial suture is present, or the cremaster is wanting, or if present, bifurcate at the distal end or bearing hooked setae; dorsum of the abdomen usually with a deep furrow between the ninth and tenth segments; scar of a caudal horn never present on the dorsum of the eighth abdominal segment; labial palpi sometimes visible as small triangular or polygonal areas caudad of the labrum. NOTODONTOIDEA.

gg. Antennae rarely very much broader near the proximal end, usually filiform, their greatest width seldom greater than that of the prothoracic legs, if greater then the cremaster is never wanting, nor bifurcate, nor with hooked setae; antennae never more than three fourths the length of the wings; epicranial suture never present; dorsum of the abdomen never with a deep furrow between the ninth and tenth segments; scar of a caudal horn usually present on the dorsum of the eighth abdominal segment; labial palpi never visible. SPHINGOIDEA.

ff. Suture adjacent to the proximal ends of the antennae and separating the front and clypeus obsolete for the greater part of its length; antennae always broadly pectinate and the width at least one fifth of the length and often wider; spiracular furrows seldom present.

SATURNIOIDEA.

PUPAE WITH FUNCTIONAL MANDIBLES

Among the Trichoptera, from which the Lepidoptera are supposed to have descended and to which they are known to be very closely related, there are many pupae which have functional mandibles. They function, though, merely to assist the pupa to escape from the cocoon. Among the generalized Lepidoptera the pupae of one super-

family, the Micropterygoidea, have large mandibles which serve the same purpose as in the Trichoptera.

Superfamily MICROPTERYGOIDEA

The most generalized lepidopterous pupae known belong to the superfamily Micropterygoidea, which includes two families, the Micropterygidae and the Eriocraniidae, characterized by the presence of functional mandibles. Except for a description of the fragments of the head by Chapman, no pupa of the Micropterygidae has been described, but this family is undoubtedly the most generalized, because the adults possess functional mandibles.

The first complete life history of any American species of Eriocraniidae was worked out by Busck and Boeving and published in the Proceedings of the Entomological Society of Washington in 1914 (Vol. XVI, pp. 151-163). These authors gave a short description of the pupa and included some excellent figures. A more detailed description is given here as this species furnishes a working basis for the study of all other lepidopterous pupae. This was made possible by the generosity of Dr. L. O. Howard, Honorary Curator of Insects, U. S. National Museum, who donated some excellent material of *Mnemonica auricyanea* collected this year by Mr. August Busck at Falls Church, Va.

The pupae of this species (Figs. 1, 2, 3) are very small, averaging 3 mm. in length in the males and 4 mm. in the females. The body is covered by a thin transparent cuticle, which shows all the imaginal parts in mature pupae, making it exceedingly difficult to distinguish pupal structures from similar structures in the adult. It is also very difficult to determine the number and position of the setae.

The head shows all the sutures usually present in generalized insects. The vertex is short, the epicranial suture fairly distinct and extending to the lateral margins of the head. The fronto-clypeal suture extends transversely between the caudo-lateral angles of the antennae. The front bears two long straight setae on each side of the meson about half-way between the antennae and the cephalic margin of the head. In the middle of the cephalic aspect, between the antennae, arises a long, fleshy, beak-like projection which contains the long tuft of hairs present in the adult. Just caudad of the front is the clypeus and laterad of these are the genae in the usual position for the Lepidoptera. The suture between the clypeus and labrum is broad and somewhat chitinized, and closely appressed to its ental surface is the tentorium, to which the mandibles are attached. The

labrum is a large fleshy projection bearing on its ectal surface six pairs of very long setae which extend beyond the lateral margin of the body, and on the ental surface two groups of much shorter setae, which project slightly beyond its caudal margin. All of the appendages of the head are free. The labial palpi are rather short, with three segments, and are somewhat enlarged and blunt at the distal end. The mandibles are exceedingly large and are attached to the ental surface of the clypeus, extending beyond the lateral margin of the body. They are heavily chitinized and serrate along the cephalo-lateral margin. The distal end is broadened and thickened, somewhat circular in outline, concave and strongly toothed. The maxillae are short and the halves are widely separated. Each half is strongly bent near the distal end, which is directed cephalad and mesad. The maxillary palpi are long, apparently with six segments, and pass from the mouth dorsad and then out towards the lateral margin of the head, making a series of curves which finally bring them between the eyes and the antennae. The distal end is folded close to the body and lies just caudad of the eye. The antennae show a long pedicel with many shorter segments and extend for more than half the length of the wings.

The thoracic segments are all more or less movable. The thorax is short, strongly elevated, and moves freely, the greater part of its exposed portion being conjunctiva. The mesothorax and metathorax are nearly equal in length, but seem to possess little power of independent motion. On the dorso-meson of these two thoracic segments and the first abdominal segment is found a strap-like cuticular thickening which is apparently for strengthening the thorax. The tegulae are indicated by the dotted lines in Figure 2 because they do not seem to be distinct pupal structures. The thoracic appendages are also free. All of the coxae are visible and usually the femora of the prothoracic and mesothoracic legs. The metathoracic legs are usually hidden beneath the wings except at the distal end, which normally curves around the caudal end of the body. The wings never extend to the caudal margin of the body.

The first seven abdominal segments are movable in both sexes. The remaining segments are not distinctly sutured and possess no power of independent movement. The genital openings are rather difficult to locate. That of the male is found as a slit-like opening on the ventro-meson of the ninth segment (Fig. 4). There are two openings in the female (Fig. 7, go), apparently located on the ventro-meson of the eighth and ninth abdominal segments.

The tenth segment is longer in the female than in the male, presumably on account of the ovipositor. The females always have the eighth, ninth, and tenth segments curved ventrad and closely appressed to the ventral surface of the body. This is shown where the caudal segments are slightly separated from the body, in Figure 2. Figures 6 and 7 give dorsal and ventral views of these caudal segments, and Figures 4 and 5 show the same segments of the male. The anal opening in both sexes is found near the caudal end of the body on the tenth segment. The spiracles are small, circular, and not produced. The mesothoracic spiracle is situated in the conjunctiva connecting the prothorax and mesothorax. Functional abdominal spiracles are visible on segments 2–7. The dorsum of the abdomen is practically covered by very minute spines arranged in groups.

The following species was examined:

Mnemonica auricyanea Walsingham.

PUPAE WITHOUT FUNCTIONAL MANDIBLES

This group includes all the superfamilies of Lepidoptera known, except the Micropterygoidea. In many of the other families the pupae possess mandibles, but they are functionless, and only indicated as small parallel tubercles or lobes.

Generalized pupae without maxillary palpi

The Hepialoidea, together with the Cossoidea and Eucleoidea, differ from all other generalized pupae possessing free abdominal segments cephalad of the fourth, because of the absence of the maxillary palpi. Some of the families included here possess lateral prolongations of the maxillae which resemble maxillary palpi (Figs. 15 and 19) and have been considered as such by some authors. These prolongations never separate from the maxillae at dehiscence, and dissection has failed to find any maxillary palpi present in the mature pupae. None of these superfamilies possess all of the sutures found in the head of the generalized type, and none of them show the long, segmented antennae present in the Eriocraniidae.

Superfamily HEPIALOIDEA

This includes a single family, Hepialidae, of which the known larvae are borers. The species in this country are of rare occurrence. Their larvae are borers in the stems of shrubs or trees. In Europe some of the species are abundant and injurious. The specimens of

Sthenopis thule were obtained through the courtesy of Mr. J. M. Swaine, of the Canadian Department of Agriculture, who obtained them from the stems of willow at MacDonald College, Quebec.

Family Hepialidae

The pupae of this family are very generalized as to the number of sutures present in the head, the number and arrangement of appendages, the comparative length of the mesothorax and metathorax, and the nearly equal length of the first seven abdominal segments. These characters are easily seen in Figures 8–10 and need no further description. The pupae are, however, exceedingly specialized as to the chitinization of the body, the spines, toothed ridges and cutting plates on the abdominal segments, and, more than all, in the soldering down of all the appendages to each other and to the body, exactly as in the most specialized of pupae. The head, thoracic segments, and the first two abdominal segments are firmly soldered together, but abdominal segments 2–7 are free in the male and 2–6 in the female.

The only consolidation of the head parts is that of the clypeus and labrum, between which the suture has been lost. The antennae, as well as all the other appendages, are very short in comparison with the length of the body. These pupae are of considerable size, that of *Sthenopis thule* being about 30 mm. in length. The larvae as far as known are borers, and their pupae have special adaptations for cutting their way to the surface. The most peculiar of these adaptations is the ventral plate on the seventh abdominal segment (best seen in Figure 9), which has not been found in any other pupae examined. The sharp ventral projections on the front also serve as cutting surfaces, but similar projections are found in many pupae, particularly among other species whose larvae are borers and in very many of the leaf-mining species. The opening of the mesothoracic spiracle has reached the normal position for most lepidopterous pupae, being between the prothorax and the mesothorax at each caudo-lateral angle of the former. The genital opening is found in the male on the meson of the ninth segment between two slightly elevated tubercles. In the female there is a single opening apparently on the eighth segment.

The following species was examined:
Sthenopis thule Strecker.

Superfamily COSSOIDEA

The pupae of this superfamily are less generalized as to head parts than the Hepialoidea, but nevertheless resemble them very closely in size, shape and arrangement of the appendages, in the num-

ber of free segments, and in the fact that all the appendages are firmly soldered to each other and to the body. The antennae, however, are of a different type, being pectinate in the Cossoidea. The metathorax varies considerably from the generalized type, being very much shorter, so that the mesothorax is about four times its length, measured on the median line. Many of the species in this superfamily have larvae which are borers, and many of the pupae are fitted to work their way to the surface of a burrow. However, the ventral plate of the seventh abdominal segment, which is so distinct in the Hepialoidea, is not present. All of the pupae have some of the body segments armed with spines and strongly toothed chitinized ridges, and a strong ridge or projection is generally present on the head. The families may be separated as follows:

a. Abdominal segments 2–6 movable in the female and 2–7 in the male; dorsum of abdominal segments armed with a row of sharp spines on the cephalic margin, and a row of setae, which are directed cephalad, on the transverse conjunctiva at the caudal margin; females without wings and antennae and larva-like in appearance. Psychidae.

aa. Abdominal segments 3–6 movable in the female and 3–7 in the male; dorsum of abdominal segments armed with a toothed ridge along each margin; sexes similar.............................Cossidae.

Family Psychidae

In this family there are no sutures apparent on the head except between the clypeus and labrum and the mandibles. The antennae are short and pectinate. The prothorax is longer and the metathorax much shorter than in the Hepialoidea, to which, however, these pupae show many resemblances. The dorsum of the abdomen has toothed chitinized ridges along the cephalic margin of some of the segments and rows of setae along the caudal margin on the transverse conjunctiva. The caudal end of the body bears two large, strong hooks directed ventrad. This description applies mostly to the males (Figs. 11–13), as the females are quite different as seen in Figure 14.

The females never leave the cocoon during their entire life and have no provision for locomotion, even in the adult. It is an astonishing fact that no pupal wings are developed, because in all other families where the adult females are apterous the pupal wings are always developed, sometimes as much as in the males. Neither are there any pupal antennae present, no eye-pieces, nor traces of maxillae. The labrum and mandibles show very distinctly, both being consid-

erably elevated. The legs are scarcely developed, being represented by transverse chitinized elevations on the venter of the thoracic segments. The abdominal segments are much as in the male. They show on the venter the proleg scars, on the dorsum the rows of toothed chitinized ridges and setae, but the body setae are much smaller and difficult to distinguish and are not represented in the figure. A single genital opening is found in the female, on the eighth abdominal segment. No hooks are present at the caudal end of the body. The abdominal spiracles are present on the first eight abdominal segments, but there is no visible opening for the mesothoracic spiracle in either sex. The only genera available for study were Thyridopteryx and Oiketicus. These resemble each other very closely and the difference between the pupae can hardly be considered as generic. The pupae of Oiketicus are larger and stouter, the males examined averaging 18 mm. in length, while those of Thyridopteryx were slenderer and only 15 mm. in length. The two genera may be separated thus:

a. Abdominal segments 2–6 with a caudal row of setae, the row on the sixth interrupted and shorter than the other rows; caudal spines stout and simple; spiracles scarcely produced beyond the surface of the body except at their cephalic margins. *Thyridopteryx* Stephens.

aa. Abdominal segments 2–5 with a caudal row of setae, no row on the sixth ever present; caudal spines slender and with a distinct tooth; spiracles distinctly produced beyond the surface of the body. *Oiketicus* Guilding.

The following species were examined:

Thyridopteryx ephemeraeformis Haworth
Oiketicus abbotii Grote

Family Cossidae

The Cossidae are borers in the larval stage and seem to be very closely related to the Hepialidae, although they resemble them less than do the Psychidae. This family has segments 3–7 of the abdomen free in the male and 3–6 in the female. There is another sexual difference to be noted, viz., the presence of an extra row of spines on the abdomen of the male. In this sex the seventh segment has two rows of spines and the succeeding segments one row; in the female the sixth is the last segment with two rows, the remaining caudal segments having but one row. The epicranial suture is not distinct in any species, but at dehiscence *Prionoxystus robiniae* shows a small piece of the vertex on each side of the meson, and this with the conjunctiva bears the eye-pieces. The lateral part of the fronto-clypeal suture is distinct and the clypeo-labral suture is always visible.

This family is usually divided into subfamilies of which two, the Cossinae and Zeuzerinae, are discussed here. Figure 15 shows the ventral surface of the head and its appendages in a member of the Cossinae, the arrangement of the other parts being the same as in the Zeuzerinae (Fig. 16).

The maxillae have prominent lateral projections in Cossinae which resemble maxillary palpi. These always adhere to it at dehiscence and are not found in Zeuzerinae. Only one genus of each subfamily was studied. The pupae are very large, those of *Prionoxystus robiniae* and *Zeuzera pyrina* being respectively 45–50 mm. and 30–35 mm. in length. The two genera studied may be separated as follows:

a. Head without a prominent cephalic projection; maxillae with an apparently segmented lateral projection on each side resembling a maxillary palpus, but adhering to the maxillae at dehiscence; antennae more than half the length of the wings and gradually tapering; abdominal segments with the cephalic ridges much larger than the caudal ones and armed with long even teeth. *Prionoxystus* Grote.

aa. Head with a prominent cephalic projection, maxillae never with an apparently segmented lateral projection on each side; antennae less than half the length of the wings and narrowed abruptly near the middle; abdominal segments with the cephalic and caudal ridges similar, the teeth short and uneven............*Zeuzera* Latreille.

The following species were examined:
Prionoxystus robiniae Peck
Zeuzera pyrina Linnaeus

Superfamily EUCLEOIDEA

The pupae of this superfamily are quite specialized as to the head parts, the epicranial suture being the only one visible in all the families. They have followed a very different line of development from the Cossoidea and Hepialoidea, because all of the generalized families retain freedom of motion between all the segments except those fixed at the caudal end of the abdomen, and between all of the appendages. The cuticle is very thin and transparent in almost all genera and the dorsum of the abdominal segments in all of them has a covering of small spines over the greater part of the segment. All of the families show the spiracles distinctly on the first abdominal segment. The only other family in which this was observed, the Nepticulidae, has a well-developed maxillary palpus. The mesothoracic spiracle of each side is in a rather unusual position in this

superfamily. The opening is on the dorsum in the normal position, and is very large, with a strongly arched cephalic margin; but the spiracle is on the ventral surface directly under the sculptured eye-piece in Megalopygidae and Eucleidae, and a little farther laterad in Pyromorphidae so that it comes partly under the antennae. The spiracle, with the adjoining parts slightly pushed aside to show their relation, is seen in Figure 21. The family Pyromorphidae being more specialized than the other two families differs from them considerably, but its relationship to them is evident. The three families included here may be separated as follows:

a. Dorsum of abdominal segments with spines on the cephalic part and a covering of coarse setae on each caudo-lateral part which does not usually extend to the meson; maxillae simple quadrangular pieces, without any lateral prolongations; a large conical tubercle caudad of each abdominal spiracle on segments 2–6; mesothorax never extending caudad to the first abdominal segment.....MEGALOPYGIDAE.

aa. Dorsum of abdominal segments with short spines, but never with a covering of coarse setae on any part; tubercles never present caudad of any of the abdominal spiracles.

  b. Labial palpi present; mesothorax with a long mesal lobe reaching on to the first abdominal segment; maxillae always less than half the length of the wings.......................PYROMORPHIDAE.

  bb. Labial palpi absent; mesothorax never with a long mesal lobe reaching on to the first abdominal segment; maxillae more than half the length of the wings................PYROMORPHIDAE.

Family MEGALOPYGIDAE

The Megalopygidae have the head and thoracic segments free, also abdominal segments 1–7 in the male and 1–6 in the female. The appendages are entirely free from each other and from the body wall. The body is soft and covered with a thin, delicate, transparent cuticle which is slightly chitinized. There are always setae on the dorsum of the abdominal segments as well as spines. The setae are found on each side of the meson on the caudal half of all the segments. The epicranial suture is distinct but all the other head sutures are obliterated. The front has a distinct projection and the mandibles show as distinctly elevated tubercles. The size and arrangement of the parts may be seen in Figures 17 and 18. This family together with the Eucleidae possesses a very peculiar eye-piece. Chapman ('94, p. 349) called attention to this structure and spoke of it as the "eye-flange". This eye-piece, in reality the sculptured portion, is free along its lateral and caudal margins and extends well out on to the antennae.

It is, however, much more wrinkled and sculptured than any other portion of the body. These eye-pieces move up and down in living pupae during respiration and allow one to see the mesothoracic spiracle underneath. The mesothorax possesses some well-defined alar ridges and its caudal margin extends in a broad curve nearly to the caudal margin of the metathorax. The large conical tubercles are found caudad of the spiracles on abdominal segments 2–6. The body of *Lagoa crispata* Packard, the only species studied, is strongly arched on the dorsum of the abdomen and is short and thick-set. Its length is about 18 mm. and the greatest breadth 10 mm.

The following species was examined:
Lagoa crispata Packard.

Family Eucleidae

The Eucleidae retain the same movable segments as the family Megalopygidae, which they strongly resemble. The pupae of Eucleidae, however, are usually only half the size of the latter, averaging about 9 mm. in length. They also retain the same head sutures, but, as in Prolimacodes, they often show a distinct furrow marking the position of the lateral part of the fronto-clypeal suture. The eye-pieces are identical with those described for Megalopygidae. The size and arrangement of parts may be seen in Figures 19, 20, and 23. In two of the genera studied, Sibine and Euclea, the maxillae, in addition to the usual cephalo-lateral extension found throughout the family (Fig. 23), have peculiar modifications in the form of long lateral prolongations extending to the antennae. Usually only the distal end of this prolongation is seen between the eye-piece and the antennae, as in Figure 19, the dotted line showing the connecting part. These two genera also have a distinct groove in each half of the maxillae, into the caudal part of which the femur of the prothoracic leg is fitted. The cephalic margin of the pronotum has a distinct median notch, which makes it appear bilobed, and each lobe is prolonged cephalad over the caudal margin of the head (Fig. 22). The mesonotum is prolonged into a rounded or pointed lobe which reaches on to the first abdominal segment. Only three genera were available for study. These may be separated by the following table:

a. Maxillae never with a lateral projection reaching to the antennae; mesothorax with a strongly carinate median line; caudal lobe of the mesonotum broadly rounded............*Prolimacodes* Schaus.

aa. Maxillae with lateral projections reaching to the antennae; mesothorax never with a strongly carinate median line.

- b. Mesonotum with the caudal lobe pointed........*Euclea* Hübner.
- bb. Mesonotum with the caudal lobe broadly rounded, almost truncate ....*Sibine* Herrich-Schaeffer.

The following species were examined:
Prolimacodes scapha Harris
Euclea delphinii Boisduval, *chloris* Herrich-Schaeffer
Sibine stimulea Clemens

Family Pyromorphidae

This family is much more specialized than either the Megalopygidae or the Eucleidae and resembles them but little. The body is flattened and has lost the power of motion except in the abdomen. Abdominal segments 2–7 are free in the male and 2–6 in the female. The appendages are also very slightly soldered together. The presence of spines on the abdominal segment, together with the absence of maxillary palpi, is considered sufficient evidence that it belongs to the superfamily Eucleoidea. Figures 24 and 25 show the essential points of its structure. The only genus available for study was Harrisina.

The following species was examined:
Harrisina americana Guérin-Méneville.

Generalized pupae with maxillary palpi

The remaining pupae which retain either free segments cephalad of the fourth abdominal segment or free appendages, have followed two distinct lines of development. In the first group the generalized condition of the body found in the Eriocraniidae has been retained as to comparative length of segments and the covering of the dorsum of the abdomen with fine spines. The metathorax is nearly always more than half the length of the mesothorax, while the prothorax tends to become shorter at the meson and broader at the lateral margins, so that each half appears triangular. In the second group, the covering of spines on the dorsum of the abdomen has been gradually changed and there is one very well-developed row of spines at the cephalic margin of each segment, with or without a similar caudal row. In this group the prothorax is longer and somewhat quadrangular in shape and the metathorax is relatively shorter. This group includes the superfamilies Tineoidea and Tortricoidea, and being much smaller than the other will be considered first.

Superfamily TINEOIDEA

The families included here possess one row of spines along the cephalic margin of the dorsum of the abdominal segments, and well-developed maxillary palpi. In one family, Prodoxidae, the primitive

covering of fine spines has been retained, but it may be easily differentiated from all other pupae bearing spines of two sizes in a similar position on account of the large maxillary palpi.

The family Heliodinidae is included here for the sake of convenience as it possesses only the cephalic row of spines on the dorsum of the abdominal segments. It is, however, much more nearly related to the Tortricoidea. The families Prodoxidae and Acrolophidae are more nearly related to the Tineidae. Of these the Prodoxidae are undoubtedly the most generalized, retaining more head sutures and a greater number of free segments, in addition to the spines mentioned above. The Acrolophidae are more generalized than the Tineidae in the matter of free segments, but have the appendages firmly soldered to each other and to the body wall. This is probably due to the fact that the larvae are sod-borers and that the pupa works its way to the surface. The families may be separated as follows:

a. Mesonotum not produced into a long caudal lobe; mesothorax seldom more than twice the mesal length of the metathorax.
  b. Abdominal segments 2–7 movable; dorsum of abdominal segments with a covering of spines on the caudal part; maxillae more than twice as long as the labial palpi.................. PRODOXIDAE.
  bb. Abdominal segments 3–7 movable; dorsum of abdominal segments never with a covering of spines on the caudal part; maxillae shorter than the labial palpi.
    c. Antennae never extending to the caudal margin of the wings; wings broadly rounded; appendages firmly soldered to each other and to the body; a lateral projection never present on each side of the tenth abdominal segment..... ACROLOPHIDAE.
    cc. Antennae extending beyond the caudal margin of the wings; wings pointed; appendages only slightly soldered together and separating at the slightest touch; tenth abdominal segment with a prominent lateral projection on each side ending in a spine................................ TINEIDAE.
aa. Mesonotum produced into a long caudal lobe; metathorax never more than one fourth the mesal length of the mesothorax. HELIODINIDAE.

Family PRODOXIDAE

In this family abdominal segments 2–7 are free in both sexes. The head shows the epicranial suture plainly, and dehiscence always takes place on the front of the head along what is apparently the fronto-clypeal suture, at least for a part of the distance, as shown in Figure 26. The front bears a prominent chitinized projection armed with two stout teeth. The lateral margin of the eye-piece extends on to the antenna for a very short distance. The appendages are very

slightly soldered to each other, but scarcely to the body wall, and separate very easily. The lateral view, Figure 27, shows the relative length of the segments. The abdominal segments, although they have developed a prominent cephalic row of spines on the dorsum, still retain the covering of very fine spines on the remainder of the segment. The eighth abdominal segment bears a pair of very stout hooks at the apices of rounded tubercles (Fig. 27a). The pupae examined measured about 10 mm. in length.

The following species was examined:
Prodoxus quinquepunctella Chambers.

Family Acrolophidae

In this family segments 3–7 of the abdomen are movable in both sexes, but the appendages are quite firmly soldered to each other and to the body wall so that they do not readily separate even at dehiscence. There is probably also dorsal movement of the second segment, as the conjunctiva is well developed and both the first and second segments separate at dehiscence. The larvae of members of this family are sod-borers and it seems quite natural that pupae with this mode of life should have their appendages soldered down at a much earlier stage than those of the leaf-miners, for instance, or of the pupae that live in cocoons. There are none of the small spines of the generalized type present on the dorsum of the abdomen in this family, but a well-developed row of spines at the cephalic margin of the segments. There are also short lateral and dorsal projections of the tenth segment, with very sharp chitinized edges, which are evidently to aid the pupa in working its way to the surface. The head bears a strongly chitinized transverse ridge near the cephalic margin of the ventral surface. Figures 28 and 29 show the arrangement of parts in a pupa of this family in which there is a remarkable development of the labial palpi. The pupae are from 15–20 mm. in length. The genera may be separated as follows:

a. Labial palpi never with distinct cutting plates near their proximal margin, the palpi not extending much over half the distance to the distal ends of the prothoracic legs; two pairs of coxae visible; spines of the abdominal segments long and narrow.
Hypocolpus Walsingham.

aa. Labial palpi with distinct cutting plates near their proximal margin, the palpi extending as far as the distal ends of the prothoracic legs; a single pair of coxae visible; spines of the abdominal segments triangular .... *Pseudanaphora* Walsingham.

The following species were examined:
Hypocolpus mortipennellus Grote
Pseudanaphora arcanella Clemens

Family Tineidae

In this family the free abdominal segments are 3–7 in the male; no females were available for examination. Segments 1–3 separate dorsally at dehiscence. The appendages are very slightly soldered together and all separate readily except the metathoracic legs and antennae, which extend beyond the caudal margin of the wings and are quite firmly fastened together, the legs being underneath the antennae.

The appendages are also slightly soldered to the body as far as the third abdominal segment. The arrangement of parts is shown in Figures 30 and 31. The fronto-clypeal suture is indicated by a clear line in the otherwise fairly well-chitinized cuticle. Segments 3–8 of the abdomen bear a cephalic row of spines on the dorsum directed caudad, while the ninth segment bears an interrupted group of spines directed cephalad. There are none of the fine spines of the generalized type of pupa present in this family. The tenth abdominal segment shows a prominent lateral projection on each side, ending in a spine. The setae of the body are very conspicuous. The pupae are about 4 mm. in length.

The following species was examined:
Tinea pellionella Linnaeus.

Family Heliodinidae

This family has usually been associated with the Yponomeutidae, but it seems from pupal characters to be more closely related to the tortricids. It is very similiar to these in arrangement of parts; the Heliodinidae, however, have longer maxillae and they plainly show that dorsal motion is possible between the second and third abdominal segments. There are also curved setae at the caudal end of the body in the genus Brenthia (Figs. 32 and 33) strongly resembling those found in the Epiblemidae. Choreutis (Figs. 34 and 35) has a small dorsal plate on the tenth segment with a strong seta at each end which appears to represent an early state in the development of a cremaster. The possession of a single row of dorsal spines on the abdominal segments, however, is like the remainder of the Tineoidea, and it is easier to classify them as such. They differ from the remainder of the superfamily in having one more free segment in the male, abdominal segments 3–7 being free in the male and 3–6 in the female. The thorax

differs markedly, too, the prothorax and metathorax being much shorter. The mesonotum has its caudal margin produced into a long lobe, while in the other families the caudal margin of the mesonotum is very slightly curved. The appendages are very slightly soldered to each other and to the body, and the wings reach on to the fourth abdominal segment. The spiracles are small, circular, and very slightly produced. The pupae are from 6–8 mm. in length. The genera may be separated as follows:

a. Body setae longer than the abdominal segments, heavily chitinized and forked at the end; maxillae, measured on the meson, about half the length of the wings; abdominal segments without deep punctures along the cephalic margin, but with a row of sharp triangular spines. *Brenthia* Clemens.

aa. Body with very short inconspicuous setae; maxillae extending to the caudal margin of the wings; abdominal segments 2–6 with a row of deep punctures along the cephalic margin, and with a row of sharp triangular spines just cephalad of the punctures. *Choreutis* Hübner.

The following species were examined:
Brenthia pavonacella Clemens
Choreutis inflatella Clemens, *gnaphiella* Kearfott

Superfamily AEGERIOIDEA

The Aegerioidea, together with the Tortricoidea retain freedom of movement in abdominal segments 3–7 in the male and 3–6 in the female. The appendages are soldered to the body so that there is no ventral movement possible between the first two abdominal segments; but there is undoubtedly dorsal movement, and at dehiscence these segments separate very distinctly from each other and the thorax, indicating that they have only recently lost their power of motion. In this superfamily is included the one family Aegeriidae. They form a very compact group in which it is hard to find satisfactory characters differentiating the genera. Moreover, pupae in good condition are difficult to obtain; but it is hoped that the characters used here in separating the genera and in defining the superfamily will hold good for those groups to which they are applied. The sexes vary considerably and it has not been possible in all cases to obtain both male and female. This superfamily has most often been associated with the Tineoidea, but pupal characters indicate a much closer relationship to the Tortricoidea. It is apparently somewhat nearer to the primitive families Eriocraniidae and Nepticulidae than the Tortricoidea, owing to the

fact that a very large maxillary palpus is present in all genera, and that spines which reach well around to the ventral surface are found on abdominal segments 2–10, especially on the tenth segment. There are no setae yet developed on the anal rise, and there is not as much consolidation of the fixed caudal abdominal segments. The seventh segment in the female seems but recently to have lost power of motion. The abdominal segments are more nearly equal in length than in the Tortricoidea.

Family Aegeriidae

The pupae of this family vary considerably in size, from the genus Aegeria, with species varying from 8–16 mm. in length, to the genera Memythrus and Bembecia, containing the largest species examined, varying from 20–25 mm. They are all provided with various forms of cutting plates for working their way to the surface, most of these being on the head, which is heavily chitinized at the cephalic end and usually has many ridges and projections, making it difficult to determine the sutures. The clypeus often bears a sharp transverse ridge, sometimes toothed, which undoubtedly serves the same purpose. The body is elongate, cylindrical, with the abdominal segments approximately equal in length, showing a generalized condition. The arrangement of parts in a pupa of this family is shown in Figures 36 and 37. It will be noted that the maxillary palpi are very large, and they remain uniformly so throughout the family. The appendages extend beyond the wings in most of the genera, but the caudal parts of these are not soldered to the body wall. The fronto-clypeal suture is always distinct along the lateral margins of the front from the proximal ends of the antennae almost to the invaginations for the anterior arms of the tentorium, but only shows transversely as a paler band of color in the strongly chitinized cuticle as indicated by the dotted line in Figure 36. Dehiscence invariably follows the course of this suture, and the front with the antennae are separated from the rest of the head parts. The epicranial suture is often obscured by the numerous elevations of the vertex and front, but it is always present. The antennae are always enlarged at the proximal end and again at the distal end, where they are somewhat club-shaped, thus differing again from the Tortricoidea. The mandibles are distinctly elevated in most genera. The wings are narrow and pointed, differing markedly from those of the Tortricoidea. They are not soldered to the body wall at their distal end. The thorax always has a carinate median ridge, which may be distinct on all the segments, and is always distinct on the prothorax and the cephalic half of the mesothorax. The alar furrows are very deep, and one edge, usually the mesal one, is sharp and heavily chitinized. There are always two rows of spines on the dorsum of some of the abdom-

inal segments, which extend around to the ventral surface. These rows of spines are always present on segments 3–6, the number varying on segments 2 and 7, while there is always one row on segments 8–10. The number of rows of spines on segment 7 differs in the sexes, there being two rows in the male and only one in the female. The spines on the tenth segment are very broad, and this row extends nearly to the ventro-meson. Each of the spines has a seta inserted near its tip, which is not heavily chitinized and therefore easily broken. There are never any setae present on the anal rise. The genera of Aegeriidae may be separated as follows:

a. Maxillae always more than half the length of the wings, generally nearly or quite equaling their length; coxae of mesothoracic legs never adjacent on the meson below the maxillae.

b. Clypeus with a prominent elevation near its caudal margin, bearing a heavily chitinized transverse ridge or series of projections which are probably to assist the pupa in cutting its way out of the burrow.

c. Clypeus with the chitinized transverse ridge produced into a distinct point on each side of the meson.

d. Mesothorax with the median carinate ridge extending nearly its whole length, very distinct on the metathorax; second abdominal segment with the two rows of spines distinct in both sexes; maxillae never reaching the caudal margin of the wings and ending opposite to the antennae; pupae averaging 20–25 mm. in length ....*Sanninoidea* Beutenmüller.

dd. Mesothorax with the median carinate ridge usually extending only along the cephalic half, never distinct on the metathorax; second abdominal segment never with two distinct rows of spines in either sex; maxillae reaching the caudal margin of the wings and ending opposite the mesothoracic legs; pupa usually 8–15 mm. in length.
Synanthedon Hübner.

cc. Clypeus with a transverse row of separate projections.
Parharmonia Beutenmüller.

bb. Clypeus not prominently elevated at its caudal margin and never bearing ridges or projections which could be used in cutting.

c. Tenth abdominal segment with eight spines in a row; caudal end of body just cephalad of the anal opening without setae.
Podosesia Möschler.

cc. Tenth abdominal segment with ten large spines in a row and two smaller ones, one on each side of the meson; caudal end of body just cephalad of the anal opening with a row of four setae which are inserted under small projections.
Memythrus Newman.

aa. Maxillae about two fifths the length of the wings; coxae of mesothoracic legs and their tarsi adjacent on the meson caudad of the maxillae............................... *Bembecia* Hübner.

The following species were examined:
Sanninoidea exitiosa Say
Synanthedon tipuliformis Clerck, *acerni* Clemens, *pictipes* Grote and Robinson, *pyri* Harris, *scitula* Harris
Parharmonia pini Kellicott
Podosesia syringae Harris
Memythrus asilipennis Boisduval, *dollii* Neumoegen
Bembecia marginata Harris

Superfamily TORTRICOIDEA

This superfamily, like the Aegerioidea, is distinguished by the presence of two rows of spines on the dorsum of most of the abdominal segments. The Tortricoidea form a more compact group than the Aegerioidea in regard to the arrangement of appendages, which varies so little throughout the families that any member of the superfamily may be easily recognized by this arrangement, together with the presence of spines on the abdominal segments. This characteristic arrangement is shown in Figures 38, 40, 41, and 44. There are often projections from the head, much as in the Aegerioidea, but there are never as many head sutures present. The thorax shows the alar furrows in many instances but they are never as well developed as in the preceding superfamily, and never have sharp chitinized edges. The abdomen also shows a greater degree of specialization and its fixed caudal segments are much more strongly consolidated, the sutures being very difficult to determine in many cases. The seventh segment has also become firmly fixed in the female.

It was found impossible to group the pupae of this superfamily according to any of the schemes of classification now in use. The four groups into which the Tortricoidea discussed in the following pages have been divided are designated as Epiblemidae, Olethreutidae, Tortricidae, and Sparganothidae. These names, however, are without any significance whatever as far as previous classifications are concerned, and are merely used as a matter of convenience. Lack of material has prevented further study in this group at present, so it has been impossible to determine the correct family names. No attempt has been made to bring the nomenclature up to date. The generic names used by Meyrick and Walsingham have been followed as nearly as possible.

The four groups or families of Tortricoidea must have had a common ancestor, but owing to the development of the maxillary palpus within the groups it would be impossible to consider one as derived from another. The line of development appears to have

been towards (1) a reduction of the spines on the dorsum of the abdominal segments, these disappearing first from the tenth segment and then from the segments cephalad of it; (2) the loss of setae on the anal rise; and (3) the development of a long cremaster. The families of Tortricoidea may be separated by the following table:

a. Body without a distinct cremaster; setae always present on the anal rise .... EPIBLEMIDAE.

aa. Body with a well-developed cremaster.

b. Ninth abdominal segment always with a distinct row of spines, especially in the males; tenth abdominal segment sometimes possessing spines; cremaster broader than long; setae always present on the anal rise.

c. Cremaster never curved ventrad, the caudo-lateral angles not produced into prominent hooks; the caudal margin usually showing three short lobe-like projections; second abdominal segment with the cephalic row of spines present and the caudal row well developed; setae of the anal rise always laterad of the anal opening .... OLETHREUTIDAE.

cc. Cremaster curved ventrad, the caudo-lateral angles produced into prominent hooks; second abdominal segment lacking the cephalic row of spines and the caudal row poorly developed; setae of the anal rise always on the caudal part of the elevation .... TORTRICIDAE.

bb. Ninth abdominal segment lacking a distinct row of spines, although a few spines are sometimes present in the males; setae never present on the anal rise; cremaster nearly always longer than broad; tenth abdominal segment never possessing spines.
SPARGANOTHIDAE.

Family EPIBLEMIDAE

The pupae belonging to this family (Figs. 38, 39) have no cremaster and there are always setae present on the anal rise. They are usually less than 10 mm. in length and slender, tapering gradually from the thoracic region to the somewhat blunt end of the body. The genus Carpocapsa is sometimes an exception as the body is often very stout, and the genus Eucosma has a cylindrical body strongly resembling the pupae of the Aegeriidae. The maxillary palpi usually extend to the proximo-lateral angles of the maxillae; only Epinotia and Enarmonia of the genera studied had shorter palpi. The maxillae are about two fifths the length of the wings, and the labial palpi are usually half the length of the maxillae. The rows of spines on the dorsum vary somewhat in the different genera. All have two rows present on abdominal segments 2–7 although the cephalic row of segment two is weak in Eucosma, Hemimene, and some species of Ancylis. Occa-

sionally the caudal row of segment seven is weak in the females of some species. As a general rule the eighth segment has but one row of spines, the cephalic one, but two rows have been found in the species of Epinotia and Eucosma, usually in the males. There is, in most genera, considerable difference between the sexes. The antennae do not vary as greatly in this family as in some others, but there is a great variation in the rows of spines, these being usually smaller and less numerous on the caudal row of segment seven in the male and on segment eight in the female. The genus Mellisopus does not show characters of sufficient importance to allow of its retention as a separate genus, and it is therefore included with Carpocapsa. The only points of difference between that genus and *Carpocapsa pomonella*, its nearest ally, are that the spiracles are oval, somewhat rectangular and slightly produced, while in *Mellisopus latiferreanus* they are large and circular but not strongly produced. There is however considerable variation. Mellisopus shows a slight carinate ridge on the metathorax, but this, again, is extremely variable.

The phylogeny of the group is extremely doubtful. If the spines on the dorsum of the abdominal segments in Eucosma were homologous with those found in the generalized pupae of Nepticulidae and others, it would certainly be the most generalized form and the others would probably follow the sequence of the table to genera. The spines, however, are much broader than any observed in the generalized types. Eucosma also shows a remarkable resemblance to the Aegeriidae, so it is probable that it is the most generalized of the Tortricoidea examined. The genera of Epiblemidae may be separated as follows:

a. With two long distinct setae present on each side of the anal rise.
  b. Caudal end of body with one row of long, heavily chitinized, flattened setae inserted along the line of the row of spines on the tenth abdominal segment.
    c. Dorsal surface of abdominal segments between the cephalic and caudal rows of spines covered, at least in part, with short triangular spines; cephalic row of spines composed of alternating large and small spines.................... *Eucosma* Hübner.
    cc. Dorsal surface of abdominal segments between the caudal and cephalic rows of spines always smooth; cephalic row of spines of approximately the same size.
      d. Portion of first coxae exposed on the meson below the maxillae more than half the length of the second coxae; body often stout, with the length scarcely three times the greatest width, but extremely variable; length averaging 10 mm.
      Carpocapsa Treitschke.

dd. Portion of first coxae exposed on the meson below the maxillae never more than half the length of the second coxae; body always slender, with the length about four times the greatest width; average length 8 mm...........*Tmetocera* Lederer.

bb. Caudal end of body with two rows of setae showing, one row of four setae inserted along the line of the row of spines on the tenth abdominal segment and another row at the caudal margin of the body.

c. Caudal row consisting of four setae; maxillary palpi always touching the proximo-lateral angles of the maxillae.

d. Caudal row of setae of two kinds, the mesal ones much slenderer than the lateral ones; maxillae less than one third the length of the wings; labial palpi about two thirds the length of the maxillae; maxillary palpus touched by the prothoracic leg ....*Hemimene* Hübner.

dd. Caudal row of setae similar; maxillae never less than one third the length of the wings; labial palpi about half the length of the maxillae; maxillary palpus touched by both prothoracic and mesothoracic legs........*Ancylis* Hübner.

cc. Caudal row consisting of two setae; maxillary palpi seldom reaching the proximo-lateral angles of the maxillae. *Epinotia* Hübner.

aa. Never with two long, distinct setae on each side of the anal rise.

b. Lateral spines of the tenth row noticeably larger than the others; setae at the caudal end of the body very short and slender, not heavily chitinized; setae of the anal rise very small and difficult to locate, usually two present on each side......*Thiodia* Hübner.

bb. Lateral spines of the tenth row not noticeably larger than the others; setae at caudal end of body long and heavily chitinized; one seta on a distinct papilla on each side of the anal rise. *Enarmonia* Hübner.

The following species were examined:

Eucosma strenuana Walker, *scudderiana* Clemens
Carpocapsa pomonella Linnaeus, *saltitans* Westwood, *latiferreanus* Walsingham
Tmetocera ocellana Schiffermueller
Hemimene incanana Clemens
Ancylis comptana Frolich, *platanana* Clemens, *diminutana* Kearfott
Epinotia saliciana Clemens, *piceafoliana* Kearfott
Thiodia signatana Clemens
Enarmonia fana Kearfott

Family Olethreutidae

The Olethreutidae (Fig. 40) include those species which possess a well-developed cremaster, usually broader than long and somewhat

flattened, bearing eight strongly chitinized, flattened, hooked setae; and usually having similar but smaller setae on the anal rise. Exceptions to this latter character are found in the genus Polychrosis, and in *Exartema ferriferanum,* which does not agree with the remainder of the genus in this respect. The group is further characterized by the presence of a well-developed row of spines on the ninth abdominal segment in all the males examined and in nearly all of the females, the exceptions being in the genus Exartema, where the spines were smaller and fewer in number. In most genera this row of spines has several additional spines on each side, usually near the meson. The only other species of the superfamily which resemble the members of this group are the species of Archips in group (b), but these have no setae on the anal rise, and very seldom have spines present on the ninth abdominal segment. *Exartema ferriferanum* is the only species among those examined which might be confused, as the row of spines on the ninth segment of the female is not well developed, while the males of *Archips cerasivorana* sometimes have a few spines present. This particular species of Exartema, however, has a prominent cephalic projection, ending in a point, directed ventrad, while the species of Archips are blunt at the cephalic end, and the bodies are usually larger and prominently enlarged in the region of the thorax. The antennae show marked sexual differences, being much longer in the males. The rows of spines on the dorsum of the abdominal segments also vary in the sexes, the caudal row of segment eight being poorly developed or lacking in many females, though well developed in the males. The row on the ninth segment is much better developed in the males. The genus Polychrosis shows a peculiar development of the spiracles. Instead of the small, produced tubular spiracles common to the Tortricoidea it appears to have them very much enlarged. This prominent enlargement around the spiracle has a deeply concave surface, and the very small tubular spiracle in the center is about one sixth of its width. A similar condition, but not so well developed, is found in *Exartema sciotoanum.* The maxillary palpi are well developed and reach the proximo-lateral angles of the maxillae in Olethreutes (b) and Polychrosis, but in Episimus, Olethreutes (a), and Exartema they are not well developed. The genera of Olethreutidae may be separated as follows:

a. Tenth abdominal segment with spines, usually three or four rows closely approximated, seldom with a single row.
  b. Long chitinized setae present on the anal rise, usually slightly shorter and narrower than those of the cremaster.
    c. With two setae on each side of the anal rise, very similar to those on the cremaster.......................*Episimus* Walsingham.

cc. With one seta on each side of the anal rise, smaller than those of the cremaster....................*Olethreutes* (a) Hübner.

bb. Setae never present on the anal rise........*Polychrosis* Ragonot.

aa. Tenth abdominal segment without spines.

b. Well-developed setae present on each side of the anal rise.

c. Maxillary palpi well developed, reaching the proximo-lateral angles of the maxillae...............*Olethreutes* (b) Hübner.

cc. Maxillary palpi short, never reaching the proximo-lateral angles of the maxillae.....................*Exartema* (a) Clemens.

bb. Without setae on the anal rise..........*Exartema* (b) Clemens.

The following species were examined:

Episimus argutanus Clemens

Olethreutes (a) *niveiguttana* Grote, (b) *malachitana* Zeller

Polychrosis slingerlandana Kearfott, *viteana* Clemens, *botrana* Schiffermueller

Exartema (a) *sciotoanum* Kearfott, *concinnanum* Clemens, *nigranum* Kearfott, *inornatum* Clemens, *permundanum* Clemens

Exartema (b) *ferriferanum* Walker

Family Tortricidae

This group is distinguished by its peculiar type of cremaster and the presence of setae on the anal rise. The maxillary palpi are not present in Peronea but are found in Argyrotoxa, where they are shorter in the male than in the female. The maxillae are usually about two fifths the length of the wings, the labial palpi nearly half the length of the maxillae. There are no spines present on the tenth abdominal segment, and they are not well developed on the second and third segments. There is always a well-developed cephalic row on the dorsum of the tenth segment, but the caudal one does not extend as far laterad in the male and is usually lacking in the female. In Argyrotoxa the cephalic row of spines on the eighth and ninth segments is on a prominent ridge which can be plainly seen on the lateral margin in dorsal view. There are always two setae present on each side of the anal rise and these are always on the caudal part of the elevation. Figures 41 and 42 show the arrangement of parts in this family and Figure 43 the dehiscence of part of the head, showing the eye-piece. The genera of Tortricidae may be separated by the following table:

a. Maxillary palpi present in both sexes; spines of the cephalic row on abdominal segments 7–9 on distinct ridges which show plainly on the lateral margins of the body, the spines extending laterad beyond the spiracles in some segments; setae on the ventral side of cremaster and between cremastral hooks not heavily chitinized and resembling the ordinary body setae......................*Argyrotoxa* Stephens.

aa. Maxillary palpi not present in either sex; spines of the cephalic row on abdominal segments 7–9 not on distinct ridges, the spines never extending laterad beyond the spiracles; setae on the ventral side of cremaster heavily chitinized, and usually not extending far beyond the caudal margin of the body..................*Peronea* Curtis.

The following species were examined:
Argyrotoxa albicomana Clemens, *bergmanniana* Linnaeus
Peronea sp., *minuta* Robinson, *logiana* Schiffermueller, var. *viburnana* Clemens

Family Sparganothidae

This family (Fig. 44) includes the species in which the cremaster is well developed and much longer than broad, except in Archips (b) and Phaecasiophora. The cremaster in nearly all species bears eight strong hooked setae which are usually not much flattened except in the genera mentioned above. There are never any setae present on the anal rise, and most of the species have no spines present on the ninth abdominal segment and none of them a well-developed row. The caudal row of the eighth segment is often lacking in the female and is poorly developed in the male. The females of *Platynota flavedana* have no cephalic row on the second abdominal segment. The members of this group include the largest of the Tortricoidea examined, most of them considerably over 10 mm. in length; the thoracic region usually appears considerably enlarged, and the abdomen is long and tapering. The vertex is shorter than in the other groups. The maxillary palpi do not reach the proximo-lateral angles of the maxillae in the males, but sometimes do so in the females. In *Platynota flavedana* the palpi appear to extend only along the cephalic margin of the prothoracic leg. The setae of the body are usually very long and prominent in this group. Sexual differences are noticed in the length of the maxillary palpi and antennae and in the development of the rows of spines on the dorsum of the abdominal segments. There are no available characters by which all the species of the genus Archips can be associated in a single group and it undoubtedly represents two genera, because there are two distinct types of cremaster present. It is also difficult to find good structural characters to separate the genera Harmologa and Archips (a). The color markings are very distinct in Harmologa, and the body is also very noticeably enlarged in the region of the first three abdominal segments, so that in ventral view the lateral margins of the wings appear curved, instead of approximately parallel as in Archips (a). The genera Epagoge and Platynota are also closely related and are grouped together by some writers. The genera of Sparganothidae may be separated as follows:

a. Transverse conjunctiva showing prominent dark brown spines scattered over a lighter brown surface.
  b. Cremaster much longer than broad, not flattened.
    c. With four setae inserted at the caudal end of the cremaster.
      d. Dorsum of second abdominal segment showing a slightly crenulate, chitinized cephalic margin, the cephalic row of spines on this segment not well developed in the males and wanting in females; head never with a cephalic projection; abdomen never with prominent cavities on the dorsum of the second and third segments; dorsum of abdomen always with darker transverse bands and spots of color.....*Harmologa* Meyrick.
      dd. Dorsum of second abdominal segment without a crenulate cephalic margin; cephalic row of spines well developed on this segment in both sexes; head often with a cephalic projection, or if not, then prominent cavities are present on the dorsum of the second and third abdominal segments; body of uniform color....................*Archips* (a) Hübner.
    cc. With two setae inserted at the caudal end of the cremaster. *Cenopis* Zeller.
  bb. Cremaster broader than long, flattened.....*Phaecasiophora* Grote.
aa. Transverse conjunctiva never showing prominent dark brown spines, surface of uniform color.
  b. Cremaster longer than broad, not flattened; labial palpi always considerably more than half the length of the maxillae.
    c. Cephalic row of spines on second abdominal segment lacking in the female; cremastral setae noticeably flattened. *Platynota* Clemens.
    cc. Cephalic row of spines on the second abdominal segment present in the female; cremastral setae not noticeably flattened. *Epagoge* Hübner.
  bb. Cremaster broader than long, distinctly flattened; labial palpi not more than half the length of the maxillae..*Archips* (b) Hübner.

The following species were examined:

Harmologa fumiferana Clemens
Archips (a) *argyrospila* Walker, *magnoliana* Fernald, *paralicla* Robinson, *obsoletana* Walker, *rosaceana* Harris
Archips (b) *cerasivorana* Fitch, *fervidana* Clemens
Cenopis chambersana Kearfott
Phaecasiophora confixana Walker
Platynota flavedana Clemens
Epagoge sulfureana Clemens

Superfamily GRACILARIOIDEA

This superfamily name is given to a number of families apparently of common origin, which have proceeded along similar lines of devel-

opment. The species are all leaf-miners and are very small, the pupae of the largest species examined being 7 mm. in length. Very few of the generalized families have been available for study, so that it is exceedingly difficult to trace the relationships existing between the more specialized families without first having carefully studied a number of more generalized forms. There is included in this group the Nepticulidae, in many respects the most generalized pupae studied, next to the Eriocraniidae, and certainly resembling the latter more than any of the other generalized forms examined. It is just at this point in our investigation that more material is needed to clear up the relationships of the groups which have apparently branched off here and have had a common ancestor with the Nepticulidae. From all the evidence at hand it seems probable that development has proceeded along two well-defined lines, the first, represented by the superfamily Gracilarioidea, having early lost the maxillary palpi while still retaining the covering of spines on the dorsum of the abdominal segments, and having developed the triangular type of prothorax; the second having retained the maxillary palpi for a much longer time, but having lost the covering of spines, while developing the same type of prothorax.

Of the second type no material has been examined which would show any intermediate stages between the families Nepticulidae and Epermeniidae. The latter family has apparently continued the line of development begun in the Gracilarioidea as it still retains the seventh abdominal segment free in the male though it is fixed in the female. The presence of the maxillary palpi precludes its derivation from the Gracilarioidea and would lead us back to some point below the Heliozelidae because this family also has lost them. As we have only the Nepticulidae for comparison, it has been assumed that this branch has arisen coordinately with them.

In the superfamily Gracilarioidea, with the exception of the family Lyonetiidae, all the pupae have free appendages, the cuticle is very slightly chitinized, and the dorsum of the abdomen is covered, in part at least, with fine spines. There is a tendency in some genera, as Lithocolletis and Ornix, towards the development of a single row of spines, so that there is often one or more rows of larger spines at either the cephalic or caudal margin, or at both margins, of the segment. This seems to indicate the way in which the rows of spines were developed in the Tineoidea and Tortricoidea. The characters which are common to all the members of the superfamily are the long vertex, which is always longer than the prothorax at the median line, scarcely ever less than twice its length and often much longer, and the long

metathorax, with the loss of a well-developed maxillary palpus in families above the Nepticulidae. Chapman described the genus Gracilaria as possessing maxillary palpi, and in two species, *sassafrasella* and *negundella*, a structure has been found (Figs. 45, 47) which may be the maxillary palpus; but there never is a distinct, oblong piece lying caudad of the eye-piece as is usually the case when the maxillary palpi are present, and of all the species of the superfamily examined these two were the only ones in which there was any doubt as to its absence. The head is in most families either produced into a prominent projection or there is a heavily chitinized cutting plate near the cephalic margin on the ventral surface. The prothorax has a tendency to become shorter on the median line and longer on its lateral margins, so that each half is triangular. In such cases the length along the lateral margin is about four times the length on the median line. In the more generalized forms the prothorax is more like the rectangular type found in the Tineoidea, but it is depressed or sunken, giving it a necklike appearance. The metathorax still retains its primitive condition, and is usually more than half the length of the mesothorax. In nearly all of the families the wings are long in proportion to the body, and in the majority they are about two thirds its length. The bodies of most of the families included here retain the generalized type found in the Eriocraniidae with a slight depression near each lateral margin in the region of the spiracles. The spiracles are usually small, circular, and slightly produced, appearing tubular. The Lyonetiidae seem to be an exception to almost every rule. They have no free segments, the appendages are all soldered to the body, and there are no spines visible on the abdomen. They seem to be more nearly related to the Bucculatrigidae than to any other family, although there are strong reasons for considering them related to the Phyllocnistidae. The following table will serve to separate the families of Gracilarioidea:

a. Maxillary palpi well developed and extending along the caudal margin of the eye; spiracles visible on the first abdominal segment.
NEPTICULIDAE.

aa. Maxillary palpi never well developed, and if present never extending as an oblong piece along the caudal margin of the eye.

b. Antennae never extending more than half the length of the wings; labrum very long and lobe-like, extending down over the labial palpi for about one fourth of their length; spines on the dorsum of the abdomen very fine and not easily distinguished.
HELIOZELIDAE.

bb. Antennae always extending at least three fourths the length of the wings, and usually equaling them in length or extending beyond their caudal margin; labrum never long and lobe-like and never

extending down over the labial palpi for one fourth of their length.

c. Appendages free, never firmly soldered to the body wall; abdomen always with some of the segments movable; dorsum of the abdomen always with spines.

d. Abdominal segments 3–7 movable in the male, 3–6 in the female; antennae and metathoracic legs not approximately equal in length and both seldom extending beyond the caudal margin of the wings.

e. Labial palpi present; caudal end of body ending in two stout spines directed dorsad; abdominal segments 3–6 with the two setae nearest the meson on the cephalic half of the segment so closely approximated that their bases touch. Tischeriidae.

ee. Labial palpi never visible; caudal end of body never with curved hooks, but the tenth abdominal segment with a prominent lateral projection on each side ending in a stout straight spine; abdominal segments 3–6 with the setae nearest the meson at the cephalic end of the segment never closely approximated ....Bucculatrigidae.

dd. Abdominal segments 4–7 movable in the male, 4–6 in the female; antennae and metathoracic legs approximately of equal length and both always extending beyond caudal margin of the wings.

e. Abdominal segments 3–7 never with two deep punctures or pits with heavily chitinized edges on the meson at the cephalic margin with one or more heavily chitinized spines adjacent; the length of abdominal segments 8–10 always greater than that of segment 7............Gracilariidae.

ee. Abdominal segments 3–7 with two deep punctures on the meson at the cephalic margin with one to three heavily chitinized spines adjacent; abdominal segments 8–10 never showing distinct segmentation, their total length less than that of the seventh segment..........Phyllocnistidae.

cc. Appendages always firmly soldered to the body; dorsum of abdomen without visible spines; abdomen without any movable segments ....Lyonetiidae.

Family Nepticulidae

These tiny species of leaf-miners average 2 mm. in length in the females and 1.5 mm. in the males. The body is flattened, with a transparent, slightly chitinized cuticle, and is white in color until the adult scales are formed. Although their size makes it difficult to determine the number of free segments, it is believed that there is some degree of motion between all of the abdominal segments except the fixed

caudal ones. There is some degree of movement between the seventh and eighth abdominal segments in both sexes, but it is apparently greater in the male. The arrangement of parts may be seen in Figures 48 and 49. The head does not show all of the sutures found in the Eriocraniidae, but the epicranial and fronto-clypeal sutures are always present. The appendages are all free and segmented as in the Eriocraniidae, and the thoracic appendages are widely separated to show all the coxae. There is a strong resemblance between this family and the more generalized members of the Eucleoidea, but the presence of the large maxillary palpi prevents their being included in that superfamily. The spiracles are visible on the first abdominal segment, and the length of the thoracic segments indicates a very generalized condition. The genital opening of the male is located as shown in Figure 48. In the females there is an area covered with setae on the venter of the eighth segment, as in the Eriocraniidae, but no openings could be accurately determined.

The following species were examined:
Nepticula nyssaefoliella Chambers, *platanella* Clemens.

Family Heliozelidae

This family includes some very small pupae which measure only 2–3 mm. in length. They have all the appendages free and widely separated. The cuticle is transparent and the body white in color, with the conjunctiva so little differentiated that it was impossible to determine the number of free segments with accuracy. Segments 2–7 in the male and 2–8 in the female have some power of motion, but whether this is movement of the whole segment in the case of the second and third, or merely dorsal movement, was not determined. The family (Fig. 50) is characterized by its short antennae, and its long labrum which projects down over the labial palpi. They also have shorter appendages than any of the other families with transparent cuticle and white bodies, because in all others the metathoracic legs and antennae extend considerably beyond the caudal margin of the wings and are often longer than the body. The epicranial suture is near the cephalic margin of the head. While this family may have retained more free segments than the Gracilariidae it is undoubtedly more specialized than some of the genera in that family. The prothorax is much longer at its lateral margins than on the meson; there is no trace of maxillary palpi, and the labial palpi are not so well developed as in the generalized Gracilariidae.

The genera included in this family have long been associated with the Elachistidae, but the pupae show no resemblance whatever to this

family. The name Heliodinidae has been applied by some authors to the genera included in this family, but Meyrick, in Lepidoptorum Catalogus, Part 13, uses this name to include the genera Brenthia, Choreutis, etc. The name Heliozelidae is used by Spuler (Die Schmetterlinge Europas, 1910) and this name has been adopted there. The genera may be separated as follows:

a. Abdomen with one or two prominent lateral setae on each side of the tenth abdominal segment; mesonotum not produced into a prominent lobe extending down on the metathorax.......... *Antispila* Hübner.

aa. Abdomen never with prominent lateral setae on each side of the tenth abdominal segment; mesonotum produced into a prominent lobe extending down on the metathorax....... *Coptodisca* Walsingham.

The following species were examined:
Antispila ampelopsisella Chambers, *cornifoliella* Clemens
Coptodisca juglandiella Chambers, *splendiforella* Clemens

Family Tischeriidae

These pupae are from 3.5–6 mm. in length and have abdominal segments 3–7 free in the male and 3–6 in the female. They are always considerably chitinized, so that the pupae vary in color from yellow to brown. The spines on the dorsum of the abdominal segments are very distinct and in some species they are of two sizes. All of the species examined except *Tischeria heliopsisella* (Fig. 54) had certain of the body setae very long, heavily chitinized, and forked at the end. These setae vary in length, but the shortest are nearly as long as the abdominal segments and are very conspicuous. The dorso-mesal setae nearest the cephalic margin were closely approximated on segments 3–6 or 7 of the abdomen so that their bases were in contact. The caudal end of the abdomen is bifurcate, and ends in two heavily chitinized hooks which are directed dorsad. The arrangement of parts may be seen in Figures 51–54. These pupae have become more specialized in certain respects than many of the Gracilariidae, although they retain one more free segment. This is noticeable in the development of the prothorax, in the distinct rows of larger spines on many of the segments, and in the strong caudal hooks. The fronto-clypeal suture shows as a clear area, indicated by the dotted line in Figure 51. This family includes two genera, Coptotriche and Tischeria, with no well-defined characters for separating them. The two species of Tischeria, *aenea* from blackberry and *malifoliella* from apple, at one time considered identical, show distinct differences in the pupae and both species resemble Coptotriche, while *heliopsisella* is very different from all the

rest. Dyar's list names but one species of Coptotriche, but three distinct types of pupae have been obtained from mines in oak leaves. Unfortunately no adults have yet emerged from these, so the species can not be determined. The genera may be separated as follows:

a. Caudal margin of the dorsum of the second abdominal segment heavily chitinized and toothed, the teeth being larger than the adjoining spines .... *Coptotriche* Walsingham.
aa. Caudal margin of the dorsum of the second abdominal segment not heavily chitinized or toothed.................... *Tischeria* Zeller.

The following species were examined:
Coptotriche zelleriella Clemens
Tischeria aenea Frey and Boll, *malifoliella* Clemens, *heliopsisella* Chambers

Family Bucculatrigidae

This family, Bucculatrigidae, including the single genus Bucculatrix, has been placed in various positions by different authors. It is quite evident that it is more specialized than most other families of the Gracilarioidea in the loss of the labial palpi and that it has proceeded along a different line of development. Nevertheless, no one can fail to see the relationship between the pupae of the Bucculatrigidae and the other members of this superfamily, particularly to some of the species of Cameraria where there is a lateral projection from each side of the tenth segment and a distinct row of larger spines on the dorsum of the abdominal segments. The lack of labial palpi, together with the spines on the abdominal segments, is sufficient to distinguish the family from all the others included in the superfamily. The arrangement of parts may be seen in Figures 55 and 56. The pupae examined had an average length of 3 mm.

The following species were examined:
Bucculatrix sp., *pomifoliella* Clemens, *trifasciella* Clemens.

Family Lyonetiidae

This family is a very difficult one to place satisfactorily by pupal characters alone, as it has completely lost the power of motion in the abdominal segments and all the appendages are soldered down. This is another of the families which has been a source of anxiety to many lepidopterists. The shape of the prothorax, the length of the vertex, together with that of the wings and appendages as compared with the body, the small tubular spiracles, and the absence of maxillary palpi seem without any doubt to indicate its relationship to the members of the superfamily Gracilarioidea and consequently it is included here.

From a careful study of the pupal characters available it seems to be more nearly related to the Bucculatrigidae than to any other family. A comparison of Figure 57 or 59 with 67 will show that the development in the Lyonetiidae has not been towards the shortening of the segments and the consolidation of abdominal segments 8–10 as in the Phyllocnistidae. Moreover, it still retains the generalized type of body found in the Nepticulidae, while the Phyllocnistidae have developed the cylindrical type. The shape of the maxillae and the position of the femur of the prothoracic leg are as in the Bucculatrigidae, and like them the Lyonetiidae have no labial palpi visible. The Lyonetiidae do not spend their pupal life within the mine, nor in a cocoon, but are exposed and fixed by the caudal end to some cross threads on the under surface of the leaf (Clemens, Tineina of N. America, 1872, pp. 189–191). The soldering down of the appendages and the loss of motion of the abdominal segments seems to be a modification to suit the new conditions of life, and is analogous to the condition found in certain families of Papilionoidea and the species of the genus Elachista, in which all power of motion is lost. Bedellia has developed certain ridges and projections, similar to those found in the Papilionoidea, which seem to be correlated with this manner of pupal life. Only two genera of Lyonetiidae were studied. These were from 4–6 mm. in length and may be separated as follows:

a. Head blunt, without a prominent projection; antennae and metathoracic legs equal in length; caudal end of body with a few straight spines on the dorsal surface of the tenth abdominal segment; body without prominent ridges.................. *Proleucoptera* Busck.

aa. Head with a long projection; antennae much longer than the metathoracic legs; caudal end of body with hooked setae; body with prominent ridges........................... *Bedellia* Stainton.

The following species were examined:
Proleucoptera smilaciella Busck
Bedellia somnulentella Zeller

Family Gracilariidae

This large family includes those pupae with free appendages and with abdominal segments 4–7 free in the male and 4–6 in the female. The antennae and metathoracic legs are of approximately the same length and both are longer than the wings. The most nearly related family, the Phyllocnistidae, differs in having on the dorsum of each abdominal segment two prominent pits or punctures with heavily chitinized edges associated with some large curved spines, in having

a much more cylindrical body with large deep furrows between the segments, and in having the fixed caudal segments very short.

The genus Gracilaria is undoubtedly the most generalized, if we consider the peculiar structures (Fig. 47) found in some species to be maxillary palpi. The tendency in the Gracilariidae is toward the loss of the maxillary palpi, and the development of the triangular type of prothorax, which usually is elevated on the median line. There is also a shortening of the maxillae and labial palpi and of all the appendages in relation to the rest of the body, and a stronger chitinization of the surface of the body tending to a soldering down of the appendages. There is also taking place the development of two sizes of spines on the dorsum of the abdominal segments and the formation of single rows of larger spines. Finally there is the development of the cremaster. There are two distinct divisions of the Gracilariidae to which subfamily names have been given. These may be separated as follows:

a. Prothorax depressed and neck-like, somewhat quadrangular in outline, the length at the lateral margin never more than twice the mesal length .... GRACILARIINAE.
aa. Prothorax usually with an elevated ridge on the meson, triangular in outline, the length at the lateral margin about four times the mesal length .... LITHOCOLLETINAE.

Subfamily *Gracilariinae*

The Gracilariinae (Figs. 45 and 46) include all the genera in which the generalized quadrangular type of prothorax has been retained. In all the genera the caudal end of the body is blunt and the tenth segment bears a row of 6 or 8 spines, larger than those on the other body segments. The labial palpi are always long and never covered by the maxillae at their proximal end. The following table will serve to separate the genera of Gracilariinae:

a. Dorsum of abdomen sparsely covered with very coarse spines, sometimes with additional fine spines.
  b. Head with a cutting plate on the ventral surface near the cephalic margin, which is usually serrate; maxillae as long as the mesothoracic legs .... *Gracilaria* Haworth.
  bb. Head with a prominent projection at the cephalic end, not a distinct plate; maxillae never as long as the mesothoracic legs. *Ornix* Treitschke.
aa. Dorsum of abdomen thickly covered with very fine spines which are almost invisible .... *Parectopa* Clemens.

Subfamily *Lithocolletinae*

In the Lithocolletinae all the genera but Acrocercops have a strongly elevated median ridge on the prothorax, and in all but Acrocercops and Marmara the proximal part of the labial palpi is covered by the maxillae so that the lateral margin can not be traced cephalad to the labrum. The genus Lithocolletis, which seems very distinct from other genera in the subfamily, includes two distinct types of larvae. On this basis the genus was divided into two groups designated as the "flat-larval group" and the "cylindrical-larval group." Dr. Chapman in 1902 (Entomologist, Vol. 35, p. 141) proposed the name Cameraria for the flat-larval group, and this name is used here as our investigation shows that the cremaster is a decided genus character, and, furthermore, that members of the same genus have the same type of cremaster. It is therefore deemed impossible, from a study of the pupal characters, that one genus could include both forms with and without a cremaster. The pupae of the cylindrical-larval group studied, moreover, showed two distinct types of cremaster, *L. lucidicostella* (Fig. 66a) having a rather broad cremaster with curved setae, while in *L. tiliacella* and *L. argentinotella* the cremaster is long and slender (Figs. 66b and 64) and the setae are T-shaped, the former having one such seta and the latter two. From the standpoint of pupal characters these would properly form three genera. It is interesting to note that Meyrick (Genera Insectorum, Part 128) places these in different sections of the genus, and that Miss A. F. Braun in her work on the "Development of the Color Pattern in Lithocolletis" (Journ. Acad. Nat. Sci. Phila., Vol. 16, Series 2, 1914) also includes them as members of different groups in her phylogenetic tree. The genera of Lithocolletinae may be separated as follows:

a. Dorsum of abdominal segments with spines of the same size; caudal margins of abdominal segments never distinctly elevated.
  b. Dorsum of each abdominal segment covered with spines for its entire length.
    c. Maxillae at least seven eighths the length of the wings; labial palpi almost half the length of the maxillae, their proximal end not covered by the maxillae; spines on dorsum of abdomen very small and inconspicuous except a row of six spines on the tenth segment.............. *Acrocercops* Wallengren.
    cc. Maxillae not more than one third the length of the wings; labial palpi about one third the length of the maxillae, their proximal end covered by the maxillae; spines on the dorsum of the abdomen small but distinct, with a few larger ones on the tenth segment.................... *Leucanthiza* Clemens.

bb. Dorsum of each abdominal segment covered with spines for about one fourth its length.

c. Head without a prominent pointed projection; maxillae more than half the length of the wings and longer than the prothoracic legs; proximal part of the labial palpi not covered by the maxillae........................*Marmara* Clemens.

cc. Head with a prominent projection; maxillae never half the length of the wings nor as long as the prothoracic legs; labial palpi covered by the maxillae at the proximal end.
Cremastobombycia Braun.

aa. Dorsum of abdominal segments covered with spines of two sizes, the caudal margins of the segments usually distinctly elevated; labial palpi always covered by the maxillae at the proximal end.

b. Caudal end of body never with a distinct cremaster.
Cameraria Chapman.

bb. Caudal end of body always with a distinct cremaster.
Lithocolletis Hübner.

Species of Gracilariidae examined:

Subfamily Gracilariinae

Gracilaria negundella Chambers, *sassafrasella* Chambers, *violacella* Clemens

Ornix prunivorella Chambers, *crataegifoliella* Clemens, *conspicuella* Dietz

Parectopa salicifoliella Chambers, *lespedezaefoliella* Clemens

Subfamily Lithocolletinae

Acrocercops venustella Clemens

Leucanthiza amphicarpeaefoliella Clemens, *ostensackenella* Fitch

Marmara salictella Clemens

Cremastobombycia solidaginis Frey and Boll

Cameraria hamadryadella Clemens, *ostryella* Chambers, *tubiferella* Clemens

Lithocolletis lucidicostella Clem., *argentinotella* Clemens, *tiliacella* Chambers

Family Phyllocnistidae

This family is very nearly related to the Gracilariidae, and the principal characters used to distinguish it are given under that family. The arrangement of parts may be seen in Figure 67. It will be noted that Phyllocnistis has long heavily-chitinized setae much as in the Tischeriidae except that they are not forked at the tip. There is a fleshy prolongation on each side of the tenth abdominal segment. This family shows a somewhat higher degree of specialization in the prothorax and labial palpi than most of the Gracilariidae. It is, however, not as much specialized as the species of Lithocolletis which have de-

veloped a cremaster, but is more like Cameraria. It may have been developed from the same stem as Cameraria, but its development is more likely to have been parallel with that of the family Gracilariidae. The body is considerably more chitinized, however, than in any member of that family. This family includes a single genus, Phyllocnistis Zeller, in which the pupae are from 3–4 mm. in length.

The following species were examined:
Phyllocnistis ampelopsiella Chambers, *insignis* Frey and Boll.

Specialized pupae with pilifers

There are two superfamilies of Lepidoptera, the Pyralidoidea and the Papilionoidea, in which the pilifers are enormously developed, and their presence is indicated in the pupa by lobes which extend from the caudo-lateral angles of the labrum towards the meson and in many instances are adjacent on the meson (Figs. 70, 72, 74, 76, 79; pf). Besides the presence of these lobes there are many other points of resemblance which would seem to indicate that these two superfamilies had a common ancestor.

Superfamily PYRALIDOIDEA

This superfamily includes all those pupae which possess lobes indicating the presence of well-developed pilifers and which do not possess clubbed antennae. This comprises the family Pterophoridae, the family Attevidae, previously included in the Yponomeutidae, and probably all of the subfamilies of Pyralididae, although pupae of only six of these were examined. The Gallerinae do not possess the lobes indicating the presence of pilifers, and differ in many other respects from most other pyralids.

The antennae are long, at least five sixths the length of the wings, and in some instances extend beyond them. The maxillae and mesothoracic legs are both long and extend to the caudal margin of the wings in most genera. The femora of the prothoracic legs are visible except in some genera of Pterophoridae. In all of these families the appendages are soldered to each other and to the body wall, but in the Pterophoridae they are very slightly soldered and separate readily. The seventh abdominal segment is free in the males of Pterophoridae and Attevidae but fixed in the female. In the Pyralididae it is fixed in both sexes. The families of Pyralidoidea may be separated as follows:

a. Maxillary palpi never present; the prothoracic and mesothoracic legs always extending cephalad between the sculptured eye-piece and the antennae; body always roughened with short spines or with small

groups of long barbed spines and setae arising from small elevations; dorsum of abdomen never with a deep furrow between the ninth and tenth segments........................PTEROPHORIDAE.

aa. Maxillary palpi usually present, if not, then the dorsum of the abdomen with a deep furrow between the ninth and tenth segments; body surface seldom roughened with spines or setae.

b. Epicranial suture never present; fronto-clypeal suture visible for about half the distance between the proximal end of the antennae and the meson; seventh abdominal segment free in the male and fixed in the female; dorsum of abdomen never with a furrow between segments nine and ten....................ATTEVIDAE.

bb. Epicranial suture usually present, if not, then the dorsum of the abdomen with a deep furrow between the ninth and tenth segments; fronto-clypeal suture never indicated; seventh abdominal segment fixed in both sexes......................PYRALIDIDAE.

Family PTEROPHORIDAE

This family possesses a curious combination of generalized and specialized characters which make its position rather difficult to determine. It has lost the maxillary palpi, the femora of the prothoracic legs are seldom visible, and the epicranial suture is present in but one genus, Pterophorus, where only a small portion of it is visible. On the other hand the seventh abdominal segment is free in the male and fixed in the female. This is clearly seen at dehiscence, for none of the abdominal segments possess much power of motion. The appendages (Fig. 70) are only slightly soldered to each other and to the body wall, and generally separate very readily. The wings are slender and pointed and, together with the other appendages, project slightly beyond the margin of the fourth abdominal segment. The clypeus, labrum, and sculptured eye-piece each bear two prominent setae in Pterophorus and Oxyptilus but in Platyptilia they are very small. There is usually a seta near the caudal margin of each gena. The proximal portion of each antenna is usually considerably widened and ridged and in Pterophorus and Oxyptilus bears long spines. The prothoracic legs are exceptionally long in this family and reach nearly to the caudal margin of the wings. The maxillae are often overlaid by the prothoracic legs for a part of their length, and sometimes are only visible for a short distance at their proximal and distal ends, the entire mesal portion being concealed. The location of the genital openings is unusual, appearing to be always on the tenth abdominal segment, which extends very far cephalad and forms a sort of ventral plate on the fixed caudal segments. In Platyptilia the plate is not so prominent and the dividing sutures between the segments may be dis-

tinguished. At the cephalic margin of this plate is a large group of hooked setae in Pterophorus and Oxyptilus, and in Platyptilia a rounded tubercle bearing four hooked setae. The abdominal spiracles are slightly produced. The mesothoracic spiracle is situated mesad of its usual position. It is also slightly produced. The peculiar spiny armature of most of the genera makes them very easy to distinguish from all other pupae. They are always found exposed, attached by the cremaster, and vary in length from 8–15 mm. The genera may be separated thus:

a. Body with long, prominent barbed spines and setae arising mostly from dorsal and lateral elevations; tenth segment with a mass of hooked setae at its cephalic margin.
  b. Femora of the prothoracic legs exposed; dorsal and lateral elevations with barbed spines of varying lengths.
  Pterophorus Geoffroy.
  bb. Femora of the prothoracic legs never exposed; dorsal and lateral elevations usually with two barbed spines which are very broad at base and on the side of each is inserted a stout straight seta.
  Oxyptilus Zeller.
aa. Body without any long barbed spines or setae, but with short, widely separated triangular projections on most of the abdominal segments; tenth segment with a rounded prominence near the cephalic margin bearing about four hooked setae.......*Platyptilia* Hübner.

The following species were examined:
Pterophorus paleaceus Zeller
Oxyptilus tenuidactylus Fitch
Platyptilia carduidactyla Riley

Family Attevidae

The genus Atteva (Figs. 72, 73), formerly included in the family Yponomeutidae, was found to differ in all its important characters from the members of that family and to be closely allied to the Pyralididae. It retains the same arrangement of setae on the clypeus and labrum as that in the Yponomeutidae. The setae at the caudal end of the body are also similar in arrangement to those in the Yponomeutidae, but the subfamily Phycitinae also have setae arranged in this way. It seems very probable that the Attevidae and Yponomeutidae arose from a common stock, but that the former branched off before motion was lost in the seventh segment of the male. In the Attevidae there is a narrow conjunctiva between the seventh and eighth segments in the male and there is slight motion possible. The eighth, ninth, and tenth segments are unusually long and distinctly segmented. There is

no epicranial suture present, and at dehiscence the eye-pieces are not separated from the other face-parts, which indicates a high degree of specialization. The maxillary palpi are present, but not as well developed as in most pyralids. The labial palpi are represented by a small polygonal area caudad of the lobes indicating the presence of pilifers which meet on the meson. The fronto-clypeal suture is present for about half the distance between the proximal ends of the antennae and the meson and it dehisces for this distance at the emergence of the imago. This family includes the single genus Atteva. The pupae of this family are from 15–20 mm. in length.

The following species was examined:
Atteva aurea Fitch.

Family Pyralididae

This family (Figs. 74, 75, 76) includes a number of subfamilies, of which only six are discussed here. The epicranial suture is present in all of these except the Epipaschiinae and a few genera of Phycitinae but the vertex is very short in all of the others, and often represented by a small triangular area, adjacent to each antenna, which does not reach to the meson. The antennae are long, at least seven eighths the length of the wings and often much longer, and the distal ends never meet on the meson. The labial palpi are visible only as small triangular or polygonal areas except in the Crambinae, which often show a large portion between the halves of the maxillae. The maxillae are always long except in the Gallerinae, usually reaching the caudal margin of the wings and sometimes extending beyond them. The maxillary palpi are present in all subfamilies except the Epipaschiinae. Each prothoracic leg is from one half to three fourths the length of the wings and its femur is always exposed. The mesothoracic legs generally extend to the caudal margin of the wings. The abdominal segments never possess spines except in the Gallerinae but are smooth or punctate. The spiracles are of different types, some being slightly produced. The location of the mesothoracic spiracle is difficult to determine in most species, there being no visible opening. The appendages are always firmly soldered to each other and the body wall. The pupae vary in length from 8–20 mm. The following table will serve to separate the subfamilies of Pyralididae:

a. Maxillary palpi always present; epicranial suture usually distinct, at least for a part of its length.
  - b. Maxillae never more than three fifths the length of the wings; dorsum of thorax and abdomen with a prominent median ridge and the segments covered with small spines........Gallerinae.

bb. Maxillae always more than three fifths the length of the wings; dorsum of thorax and abdomen never with a median ridge or with small spines on the segments.

c. Cremaster absent or never long and well developed; furrows usually present on the dorsum between the ninth and tenth abdominal segments, or on the lateral part of the tenth segment; head usually rounded; body never with a shouldered appearance; labrum in its normal position.

d. Caudal end of body with all the setae straight and very short; cremaster short and blunt; lateral margins of the dorsum of tenth abdominal segment with prominent deep furrows extending caudad to the proximal end of the cremaster; a large portion of the labial palpi often exposed .... CRAMBINAE.

dd. Caudal end of body never with all the setae straight, but usually long and hooked; lateral margins of the tenth abdominal segment never with deep furrows unless they are extensions of the dorsal furrow between the ninth and tenth segments; labial palpi never with more than a very small triangular or polygonal area exposed.

e. Dorsal furrow, if present between the ninth and tenth abdominal segments, with a crenulate margin; mesothoracic spiracles never tubular, but slit-like and not plainly indicated; caudal end of body without a cremaster, and bearing a transverse row of six or eight slender hooked setae.................... PYRALINAE.

ee. Dorsal furrow usually present between the ninth and tenth abdominal segments but never with a crenulate margin, if the dorsal furrow is absent then the mesothoracic spiracles produced and tubular; cremaster wanting or very short.................. PHYCITINAE.

cc. Cremaster always present and well developed; dorsal furrows never present between the ninth and tenth abdominal segments or on the lateral part of the tenth segment; head blunt; body with a distinctly shouldered appearance; labrum always cephalad of its normal position.............. PYRAUSTINAE.

aa. Maxillary palpi never present; epicranial suture never visible for any part of its length; dorsal furrow between the ninth and tenth abdominal segments strongly curved caudad and apparently lined with a fringe of short setae....................... EPIPASCHIINAE.

Subfamily *Gallerinae*

The pupae of this subfamily are very different from most pyralids and there is some doubt as to whether they should be included with

this family. The lobes which indicate the presence of pilifers are not well developed and the maxillae are short (Fig. 69). The body is short and thick and covered on the dorsum of the thorax and abdomen with short spines. A strongly elevated median ridge is also present on the thorax and on the first eight abdominal segments. The prothorax is very long, at least half the length of the mesothorax.

The following species was examined:

Galleria melonella Linnaeus.

Subfamily *Crambinae*

The pupae of the Crambinae are easily recognized by the peculiar form of the short, blunt cremaster and the deep lateral grooves on the tenth abdominal segment. Some of the species show a large portion of the labial palpi, indicating that this subfamily is one of the more generalized. The maxillae reach almost to the caudal margin of the wings and the tips of the mesothoracic legs meet on the meson just caudad of the maxillae. The segments are almost smooth, never punctate.

The following species were examined:

Crambus vulgivagellus Clemens, *trisectus* Walker, *caliginosellus* Clemens.

Subfamily *Pyralinae*

The species of this subfamily resemble closely the genera Plodia and Ephestia of the Phycitinae. There scarcely seems to be more than generic differences between them. The epicranial suture is present and the vertex always extends to the meson. The maxillary palpi are well developed and usually reach the proximo-lateral angles of the maxillae. There is never a cremaster present, but a transverse row of hooked setae at the caudal end of the body. The two genera studied may be separated as follows:

a. Dorsum of abdomen with a furrow between the ninth and tenth segments, the caudal margin of the furrow distinctly crenulate. *Pyralis* Linnaeus.

aa. Dorsum of abdomen without a furrow between the ninth and tenth segments.................................*Hypsopygia* Hübner.

The following species were examined:

Pyralis farinalis Linnaeus

Hypsopygia costalis Fabricius

Subfamily *Phycitinae*

This group is, for the most part, easily distinguished from other pyralids by the presence of the suture on the dorsum of the abdomen between the ninth and tenth segments, the presence of maxillary palpi, and, usually, of the epicranial suture. Of the genera examined, Ephestia and Plodia alone were without this dorsal furrow, and they possess tubular spiracles on the mesothorax. These two genera seem rather more closely related in many respects to the Pyralinae than to the Phycitinae. The maxillary palpi always extend to the proximo-lateral angles of the maxillae, and the epicranial suture is present in all genera examined but Pinipestis and Mineola, though it is very near to the suture between the head and prothorax. The vertex is usually represented by a small triangular area adjacent to each antenna. The lobes enclosing the pilifers meet on the meson in some genera. The genera of Phycitinae may be separated as follows:

a. Dorsal surface without a prominent furrow separating the ninth and tenth abdominal segments; mesothoracic spiracles tubular.
  b. Abdominal segments punctate; maxillae reaching the caudal margin of the wings........................... *Ephestia* Guenée.
  bb. Abdominal segments smooth; maxillae never reaching the caudal margin of the wings........................... *Plodia* Guenée.
aa. Dorsal surface with a prominent furrow separating the ninth and tenth abdominal segments; mesothoracic spiracles never tubular, their exact position usually difficult to determine.
  b. Body depressed; tenth abdominal segment with the caudal end distinctly margined and with six straight setae inserted on the ventral side of the margin........................ *Acrobasis* Zeller.
  bb. Body never depressed; tenth abdominal segment never with the caudal end distinctly margined or with setae inserted on the ventral side of the margin.
    c. Caudal end of body with four long hooked setae, and on each side of these a short spine or hooked seta extending laterad.
      d. Tenth abdominal segment with lateral spines very different from the caudal setae.
        e. Ninth abdominal segment with a lateral spine on each side similar to those on the tenth segment, and two hooked setae on the dorsum adjacent to the caudal margin; caudal hooked setae equidistant...*Mineola* Hulst.
        ee. Ninth abdominal segment without lateral spines or hooked setae on the dorsum adjacent to the caudal margin.
          f. Caudal spines not adjacent; equidistant; of equal length .... *Meroptera* Grote.

ff. Caudal spines adjacent; two of them shorter than the other two......................*Psorosina* Dyar.

dd. Tenth abdominal segment with lateral hooked setae similar to the caudal setae....................*Canarsia* Hulst.

cc. Caudal end of body with a transverse row of six long hooked setae of equal length; epicranial suture never present; head with a prominent pointed cephalic projection. *Pinipestis* Grote.

The following species were examined:
Plodia interpunctella Hübner
Ephestia kuehniella Zeller
Acrobasis rubrifasciella Packard
Mineola indiginella Zeller
Meroptera pravella Grote
Psorosina hammondi Riley
Canarsia ulmiarrosorella Clemens
Pinipestis zimmermani Grote

Subfamily *Pyraustinae*

This group is distinguished by the peculiar "shouldered" appearance of the body, caused by the great width of the thorax as compared with the head and by the position of the labrum, which is always cephalad of its normal position and often located near the cephalic end of the body. There is never a furrow on the dorsum between the ninth and tenth abdominal segments. The maxillary palpi are always present and only a very small portion of the labial palpi is exposed. The epicranial suture is present in all genera. The mesothoracic legs and antennae, together with the metathoracic legs which are hidden by them, usually extend beyond the caudal margin of the wings. The mesothoracic spiracles often have peculiar ridges along their caudal margin which are sometimes covered with setae. Similar ridges are found in certain families of Papilionoidea and Notodontoidea. The shape of body and arrangement of parts in the Pyraustinae resembles that of certain Sphingidae, and would seem to indicate that the Pyraustinae are not as closely related to the Phycitinae as the other subfamilies, which all show a very close relationship. The genus Pyrausta as understood at present probably does not represent a natural group. Of the species studied *P. fissalis* and *P. illibalis* have long narrow cremasters of similar type, while *P. futilalis* and *P. insequalis* have short broad cremasters of rather different types. There is also great variation in the length of the appendages, but this is not such a decided generic character as the form of the cremaster. This

subfamily includes the largest pyralids examined. The genera of Pyraustinae may be separated by the following table:

a. Setae of the cremaster always hooked and equal in length to the cremaster or sometimes longer; the other appendages never extending beyond the caudal margin of the wings.
  b. Setae of the thorax and abdomen very long, heavily chitinized, and forked at the distal end, usually much longer than the segments; mesothorax and metathorax having a deep oblong pit with strongly chitinized edges at the base of each wing. *Phlyctaenia* Hübner.
  bb. Setae of the thorax and abdomen never prominent, scarcely ever visible; mesothorax and metathorax never having a deep oblong pit at the base of each wing.
    c. Mesothoracic spiracle with a prominent elevation adjacent to the caudal margin, which bears several ridges fringed with setae; front with a distinct tubercle or small ridge at the base of each antenna........................*Desmia* Westwood.
    cc. Mesothoracic spiracle without any prominent elevation adjacent to the caudal margin; front without a tubercle or ridge at the base of each antenna...........*Pantagrapha* Lederer.

aa. Setae of the cremaster either straight and equal in length to the cremaster, or hooked and much shorter than the cremaster; the other appendages often extending beyond the caudal margin of the wings.
  b. Prothorax with a distinct tubercle on each side of the meson; cremastral setae straight and spread out fan-like. *Tholeria* Hübner.
  bb. Prothorax without a distinct tubercle on each side of the meson; cremastral setae hooked, and not spread out fan-like. *Pyrausta* Schrank.

The following species were examined:

Phlyctaenia ferrugalis Hübner
Desmia funeralis Hübner
Pantagrapha limata Grote and Robinson
Tholeria reversalis Guenée
Pyrausta fissalis Grote, *illibalis* Hübner, *futilalis* Lederer, *insequalis* Guenée

Subfamily *Epipaschiinae*

Only one species of this group has been examined, so no very definite statements can be made regarding it. The species examined seems to differ mainly in the absence of the maxillary palpi, which are present in all of the other subfamilies. The epicranial suture is not visible and the labrum is slightly cephalad of its normal position. The dorsum of the abdomen shows a decided furrow between the ninth

and tenth segments which is strongly curved caudad and apparently covered with some fine whitish setae, but this appearance may be due to the fine striations present. The caudal margin of the furrow is crenulate. There is a very short cremaster present, bearing a small group of hooked setae, which are more than half as long as the tenth segment.

The following species was examined:
Lanthape platanella Clemens.

Superfamily PAPILIONOIDEA

The members of this superfamily are distinguished by the possession of lobes indicating the presence of well-developed pilifers and by their distinctly clubbed antennae. The genus Oeneis is an exception, however, in not having the lobes well developed; but this is probably due to specialization, as it seems very closely allied to the Satyrinae, especially in the length of the prothoracic legs. Many of the Papilionoidea have prominent ridges and tubercles on the surface of the body, but there are also many genera in which the body surface is quite smooth and destitute of tubercles and ridges. The epicranial suture is present in three families, Megathymidae, Hesperiidae, and Lycaenidae. There has been a great deal of discussion and disagreement over the arrangement and subdivision of the families of the Papilionoidea. Some have divided it into two superfamilies, Hesperioidea and Papilionoidea, but the pupae show no characters to warrant such a division. The family Lycaenidae has been considered by many as the most specialized, or among the most specialized, of the families, yet it still retains the epicranial suture. In this family, however, the labial palpi are entirely concealed except in the case of the aberrant genus Feniseca, and the shortening of the prothoracic legs is similar to the condition found in the Nymphalidae. It is impossible without further study of existing forms and a larger series of species to discuss fully the relationships between the different families. It is sufficient for the present to state that the Lycaenidae seem more nearly related to the generalized Hesperiidae, but have developed in a similar manner to the Nymphalidae, and that the Pieridae, Papilionidae, and Nymphalidae seem very closely related. The families of Papilionoidea may be separated as follows:

a. Proximo-lateral angles of the maxillae extending laterad to the eye-pieces.
   b. Maxillae never reaching the caudal margin of the wings; wings adjacent on the meson caudad of the maxillae. .Megathymidae.

bb. Maxillae always extending to the caudal margin of the wings and sometimes beyond; wings never adjacent on the meson. HESPERIIDAE.

aa. Proximo-lateral angles of the maxillae never extending laterad to the eye-pieces.

b. Mesothoracic legs never extending cephalad to the eye-pieces.

c. Epicranial suture always present; head without projections; exposed part of maxillae never as long as the wings. LYCAENIDAE.

cc. Epicranial suture never present; head always with prominent projections; exposed part of maxillae usually as long as the wings.

d. Head with two prominent projections, one at each cephalo-lateral angle; metathoracic wings visible in ventral view. PAPILIONIDAE.

dd. Head with a median projection; metathoracic wings not visible in ventral view. . . . . PIERIDAE.

bb. Mesothoracic legs extending cephalad to the eye-pieces and for a short distance between the sculptured eye-piece and the antenna. NYMPHALIDAE.

Family MEGATHYMIDAE

The Megathymidae, or giant skippers, are evidently the most generalized of the Papilionoidea although they differ but little from the more generalized Hesperiidae, some doubt existing as to whether they show enough difference to warrant their being considered as a distinct family. However, as only one pupa of this family has been seen by the writer and as that had lost some of the face-parts so that a complete description can not be given, no very definite stand can be taken here as to its position in the superfamily. The members of the superfamily Papilionoidea, as a general rule, possess but little freedom of motion in the free segments and these are rarely capable of being telescoped. In the Megathymidae not only are the free segments capable of a great deal of motion and of being telescoped, but there appears to be dorsal motion possible between the third and fourth abdominal segments, and the seventh abdominal segment appears to possess freedom of motion in the male. The abdominal segments are of nearly equal length, and the eighth, ninth, and tenth are distinctly segmented. These characters, however, appear to be retained in such generalized Hesperiidae as the genera Calpodes and Amblyscirtes, in which if all the above-mentioned segments do not retain freedom of motion they have certainly but recently lost it. In placing this family in the Papilionoidea it has been assumed that the pupae possess lobes indicating the presence of pilifers, but these parts

were absent in the pupa examined. The labial palpi are represented by a small triangular area, but it is not known whether or not maxillary palpi are retained. The maxillae are much shorter than in the Hesperiidae, being only about two thirds the length of the wings, but this indicates nothing as to their position, as both generalized and specialized pupae possess short maxillae. None of the other appendages are longer than the maxillae except the wings, which lie adjacent on the meson caudad of the maxillae. The epicranial suture is present and the vertex is of equal length throughout, being about one fifth the length of the prothorax measured on the meson. The entire body surface is covered with a whitish bloom, and on the dorsum of abdominal segments 7–10 there is in addition a dense covering of rather coarse setae. The pupa examined was 40 mm. in length and about 10 mm. in breadth, and belonged to the genus Megathymus.

The following species was examined:
Megathymus yuccae Boisduval and Le Conte.

Family Hesperiidae

The Hesperiidae retain considerable freedom of motion of the abdominal segments, and in many genera it would seem that dorsal motion is possible between the third and fourth abdominal segments and that the seventh abdominal segment is free in the male, or at least that they have only recently lost the power of motion. The epicranial suture is present in all genera, and the vertex is about one fifth the length of the prothorax measured on the meson, while the lateral margins are considerably longer. The labrum in most genera is considerably cephalad of its normal position. The antennae never reach to the caudal margin of the wings but are from two thirds to three fourths of their length. The prothoracic legs are about half the length of the wings, the mesothoracic usually two thirds of the same, while the metathoracic pair is seldom visible. The maxillae always extend to the caudal margins of the wings and frequently considerably beyond. The mesothoracic spiracles usually have a peculiar kind of plug or plate which seems to form an external closing apparatus or guard, while some have prominent tubercles caudad of the opening, usually with a dense covering of setae. The thorax and abdomen usually have a more or less dense covering of setae, and some of the species have the entire body covered with a whitish bloom, which is of comparatively rare occurrence among lepidopterous pupae. The abdomen frequently has a furrow on the dorsum between the ninth and tenth segments, similar to the furrows found in the Pyralididae but never so deep. The cremaster in all genera is more or less trian-

gular, with hooked setae on the distal end, and frequently has an impressed triangular area on the dorsum. The classification of the Hesperiidae has long been in dispute, and with the limited amount of material available for examination it is impossible to state just how a classification of the pupae would agree with any of the proposed schemes. It is believed, however, that Scudder's arrangement would probably be followed, as the material available falls readily into his groups. As to the relationship between these groups there might be some difference of opinion. The pupae at first sight are readily divided into two groups, one with the abdominal segments caudad of the fourth considerably shortened, possessing narrow flanged plates on the movable segments which prevent the telescoping of the body, and with the segmentation indistinct between the fixed caudal segments (Fig. 77). This group also has the body prominently convex on the dorsum of the mesothorax and on the entire ventral surface of the thorax and abdomen. The labrum is cephalic in position. The other group possesses abdominal segments of more nearly equal length, having distinct sutures between the fixed caudal segments and the movable segments capable of being telescoped. This group has apparently just recently lost the power of motion in the seventh abdominal segment of the male and dorsal motion between the third and fourth abdominal segments. The body is shaped like the majority of lepidopterous pupae, and the labrum never quite reaches the cephalic margin of the body. Of this group, the genera possessing maxillae extending beyond the caudal margin of the wings, Calpodes (Fig. 78) and Amblyscirtes, are undoubtedly more generalized, not on account of the maxillae, but because in all the other members of the group there is considerably more consolidation of the caudal abdominal segments, so that they seem intermediate in position between the genera mentioned above and the first group. The following table will serve to separate the genera of Hesperiidae:

a. Abdominal segments 5–7 never with an elevated ridge or flanged plate along the cephalic margin and always capable of being telescoped; body never with a prominent convexity on the ventral surface in the region of abdominal segments 1–4.
  b. Maxillae extending free for a considerable distance beyond the caudal margin of the wings.
    c. Maxillae extending beyond the caudal margin of the body; head with a long cephalic projection............ *Calpodes* Hübner.
    cc. Maxillae never extending beyond the caudal margin of the body; head never with a long cephalic projection.
Amblyscirtes Scudder.

bb. Maxillae never extending free beyond the caudal margin of the wings.

c. Body with a dense covering of long setae and whitish bloom; mesothoracic spiracle with a strongly elevated oval area adjacent to its caudal margin, this area chitinized in the center and surrounded by a dense band of short setae with a longitudinally striate chitinized rim forming an outer margin. *Pholisora* Scudder.

cc. Body sparsely covered with short inconspicuous setae; dense whitish bloom never present; mesothoracic spiracle with a somewhat circular elevation adjacent to its caudal margin, which is entirely covered with setae. . . . . *Thanaos* Boisduval.

aa. Abdominal segments 5–7 with an elevated ridge or flanged plate along the cephalic margin which prevents their being telescoped; body with a prominent convexity on the ventral surface in the region of abdominal segments 1–4.

b. Mandibular area with distinct tubercles which are usually black and bearing stout setae; head slightly narrower than the mesothorax.

c. Mesothoracic spiracle semicircular in outline, the opening circular, a broad thick band of setae around the caudal half.

d. Dorsal furrow or depression on the ninth abdominal segment with its caudal margin distinctly crenulate; ventral surface of cremaster with an elongate furrow broadened out at the distal end of the cremaster. . . . . *Thorybes* Scudder.

dd. Dorsal furrow or depression on the ninth abdominal segment not distinctly crenulate; ventral surface of cremaster with a triangular depression broad at the proximal end and narrowed to the distal end of the cremaster. *Epargyreus* Hübner.

cc. Mesothoracic spiracle semicircular in outline, the opening circular and surrounded by a broad thick band of setae, and caudad of this a distinctly elevated chitinized ridge forming an outer margin. . . . . *Cocceius* Godman and Salvin.

bb. Mandibular area smooth, without tubercles; head as broad as the mesothorax . . . . *Eudamus* Swainson.

The following species were examined:

Calpodes ethlius Cramer
Amblyscirtes vialis Edwards
Pholisora catullus Fabricius
Thanaos brizo Boisduval and Le Conte, *lucilius* Lintner
Thorybes daunus Cramer
Epargyreus tityrus Fabricius
Cocceius pylades Scudder
Eudamus proteus Linnaeus

Family Lycaenidae

The Lycaenidae are small pupae, between 8 and 15 mm. in length, which have the general shape of arctians although they are generally less curved on the ventral surface (Fig. 79). They retain a small portion of the vertex on each side and the epicranial suture usually touches the caudal margin of the head at the meson, making each half of the vertex triangular. The lobes indicating the presence of pilifers always meet on the meson except in the genus Feniseca. The antennae always extend to the caudal margin of the wings and lie adjacent on the meson, concealing the distal ends of the maxillae. The prothoracic legs are shorter than usual, varying from two fifths to one third the length of the wings. The mesothoracic legs are about half the length of the wings and the metathoracic pair are never visible. The body is usually quite free from projections or elevations, Feniseca being the only exception known, and it bears small rounded tubercles on its dorsal surface. The head is limited to the ventral surface of the body, and the suture between it and the prothorax is located on the cephalic margin of the body, sometimes forming a slight ridge. The prothorax is longer than is usual in Papilionoidea, being about half as long as the mesothorax. There is little, if any, motion possible between any of the abdominal segments, and they fit together so as to form a smooth surface. Even the pupal skin after dehiscence shows no separation of the abdominal segments. The surface of the thorax and abdomen is covered with a reticulation of fine elevated lines with small papillae at their intersections and usually in the spaces between. These papillae usually bear cuticular appendages, of various types, the most peculiar being the fungiform type of the genera Chrysophanus and Heodes. There is no cremaster present in any member of the family. The ventral surface of the abdomen frequently bears groups of small hooked setae. The genital openings are usually obscured. The anal opening is peculiar, in many forms being transverse instead of longitudinal. The mesothoracic spiracles are closed by a plug or plate which fills up the opening and usually presents a honeycombed appearance. The following table will serve to separate the genera of Lycaenidae:

a. Exposed portion of maxillae never more than three fifths the length of the wings; cuticular appendages of the body never fungiform.

  b. Ventral surface of the body never with hooked setae caudad of the anal opening; thorax and abdomen usually densely covered with spiculate cuticular appendages; exposed portion of maxillae scarcely more than half the length of the wings.

c. Ventral surface of ninth abdominal segment with a group of hooked setae on each side of the meson.

d. Thorax with the median line slightly elevated; raised lines of the reticulations very prominent; papillae short, cylindrical. ....*Incisalia* Minot.

dd. Thorax with the median line never elevated; raised lines of reticulations not prominent; papillae conical. *Uranotes* Scudder.

cc. Ventral surface of ninth abdominal segment never with hooked setae on each side of the meson.

d. Ventral surface of ninth abdominal segment with a group of straight cuticular appendages on each side of the meson; setae on body very dense and about one fourth the length of the abdominal segments; papillae conical. *Mitura* Scudder.

dd. Ventral surface of ninth abdominal segment without cuticular appendages of any kind; setae of body not dense, but long, usually half the length of the segment; papillae short, cylindrical...................*Thecla* Fabricius.

bb. Ventral surface of body with hooked setae caudad of the anal opening; papillae most numerous in the spiracular region; thorax and abdomen sparsely covered with short cuticular appendages with very minute spicules; exposed portion of maxillae three fifths the length of the wings.

c. Papillae of the spiracular region confined to an area caudad of the spiracle; spiracle of the second abdominal segment not adjacent to the wing...................*Cyaniris* Dalman.

cc. Papillae of the spiracular region surrounding the spiracle; spiracle of the second abdominal segment adjacent to the wing, the distance between them less than the width of the spiracle ....*Rusticus* Hübner.

aa. Exposed portion of the maxillae more than three fifths the length of the wings.

b. Body of typical lycaenid shape, never flattened at the caudal end; cuticular appendages fungiform.

c. Fungiform cuticular appendages small and inconspicuous, not visible with a low-power lens; color light yellowish brown, not spotted........................*Chrysophanus* Hübner.

cc. Fungiform cuticular appendages large and conspicuous, easily visible with a low-power lens; color dark brown with black spots ....*Heodes* Dalman.

bb. Body with the caudal end flattened and curved slightly ventrad. *Feniseca* Grote.

The following species were examined:

Incisalia niphon Hübner
Uranotes melinus Hübner

Mitura damon Cramer
Thecla acadica Edwards, *calanus* Hübner, *liparops* Boisduval and Le Conte
Cyaniris ladon Cramer
Rusticus scudderi Edwards
Chrysophanus thoe Boisduval
Heodes hypophleas Boisduval
Feniseca tarquinius Fabricius

Family Papilionidae

The pupae of this family are usually long and slender, tapering gradually to the pointed caudal end, which is called the cremaster although it seldom resembles a true cremaster, and extends very little beyond the anal opening. The body always has two prominent cephalic projections, one at each cephalo-lateral angle of the head, a less prominent lateral projection on each side the metathorax at the base of each wing, and a low median carinate ridge which extends along the prothorax on to the mesothorax for about half its length, where it forms a more or less prominent projection. From this prominence the ridge divides, the remainder of its course being on the metathorax, the divisions sometimes extending to the abdomen to form the dorso-lateral abdominal ridges. There is also usually present a lateral ridge on each side. These four ridges are continued to the end of the body, and are often present on the tenth segment or on the cremaster when absent from the remainder of the abdomen. On the ventral surface there is usually a ridge on each side of the face-parts, beginning at the cephalic projections and extending to the proximo-lateral angles of the maxillae.

The labrum is in its normal position and the lobes which indicate the presence of pilifers seldom meet on the meson, but are separated by a small portion of the labial palpi. The epicranial suture is never present, and the proximal ends of the antennae approach each other very closely on the dorsal surface of the head. The antennae never extend as far caudad as the wings. The wings are usually somewhat pointed on the ventral surface near the meson and the metathoracic wing is always visible here, extending for a considerable distance caudad of the mesothoracic wings. The maxillae always extend to the caudal margin of the wings. The legs are of the length usual in lepidopterous pupae with the exception of the genus Iphiclides, in which the prothoracic legs only are about the usual length, the mesothoracic legs ending before the former—a very rare occurrence in this order. The genital openings are located in the usual positions, those of the

female being confluent on the ventro-meson of the eighth and ninth abdominal segments. Just caudad of the genital openings, at the cephalic margin of the tenth abdominal segment is a small tubercle on each side of the meson closely appressed to the surface of the body. The caudal end of the body bears a mass of very short hooked setae. The fourth, fifth, and sixth segments are movable, although they fit closely together to form an even surface and are not capable of telescoping. At dehiscence they separate, showing deep incisions. The genera of Papilionidae may be separated as follows:

a. Body surface without distinctly carinate ridges; dorsal surface of abdomen always with a row of small rounded tubercles on each side of the meson, the largest on segments 4–7, and usually a row of smaller tubercles on each side of the spiracles; ventral surface with two distinct tubercles on each leg, a transverse row near the caudal margin of the mesothoracic wings, and often on the veins near the margin ....*Papilio* Linnaeus.

aa. Body surface with distinctly carinate ridges, but never with small rounded tubercles on the abdomen, occasionally with very minute tubercles on the wings and other appendages.

b. Body without prominent lateral expansions of the abdominal segments or dorsal carinate ridges.

c. Body with a very low dorso-mesal ridge on the thorax with a small mesothoracic elevation; a prominent carinate ridge at each lateral margin of the body and no dorso-lateral ridge; cephalic projections large and prominent; body very strongly convex on the ventral surface in the region of the wings. *Euphoeades* Hübner.

cc. Body with a low dorso-mesal ridge on the thorax ending in a very prominent mesothoracic elevation; a very low dorso-lateral and lateral ridge on each side of the abdomen; cephalic projections not very large; body never strongly convex on the ventral surface.........................*Iphiclides* Hübner

bb. Body with prominent lateral expansions of the first four abdominal segments, making this the widest part of the body; abdominal segments with dorsal carinate ridges on each side of the meson, most prominent on segments 5–7, which are highest in the middle of each segment and curve to each margin, giving it a scalloped appearance in lateral view..........*Laertias* Hübner.

The following species were examined:

Laertias philenor Linnaeus

Iphiclides ajax Linnaeus

Euphoeades troilus Linnaeus, *palamedes* Drury

Papilio daunus Boisduval, *eurymedon* Boisduval, *rutulus* Boisduval, *glaucus* Linnaeus, *polyxenes* Fabricius, *thoas* Linnaeus, *machaon* Linnaeus, *zolicaon* Boisduval, *brevicauda* Saunders

Family Pieridae

The pupae of this family resemble the Papilionidae very strongly as to the general shape of the body and arrangement of ridges and projections. They are much smaller, however, and are easily recognized by the fact that they possess a single median cephalic projection instead of two cephalo-lateral projections as do the Papilionidae. The epicranial suture is never present. The labrum is usually slightly cephalad of its normal position and a small portion of the labial palpi is always exposed. The maxillae vary in length from two thirds the length of the wings to extending slightly beyond their caudal margin. The legs are of normal length. The antennae are more distinctly clubbed than in the Papilionidae and sometimes reach the caudal margin of the wings. The caudal end of the body is very like that of the Papilionidae except that the four ridges are seldom present, and the hooked setae are inserted in a slight concavity. The genital openings are in the usual positions. On the ventral surface of the tenth abdominal segment there is a low ridge, circular in outline, which encloses the anal opening and terminates at its cephalic end in a small tubercle on each side of the meson. These tubercles are located just caudad of the genital openings. Similar tubercles and ridges are found in the Nymphalidae, but they are rather more prominent in that family. Tubercles without the ridges occur in the Papilionidae.

There is very little question as to whether or not the Pieridae and Papilionidae are related, but which is the more specialized seems to be a questionable point with all workers in the group. Aside from the question of prominences or projections, which, after all, seems a matter of small importance, there is little of fundamental difference between the two families excepting the length of the thoracic segments, which are more generalized in the Papilionidae, and the ridges and tubercles just mentioned on the ventral surface of the Pieridae, which resemble the Nymphalidae. The Nymphalidae certainly seem to be the most specialized of the Papilionoidea, although this is another much debated question. The two families have undoubtedly been developed from a common ancestor and represent parallel lines of development. The genera of Pieridae may be separated by the following table:

a. Distance from the cephalic margin of the prothorax to the distal end of the cephalic projection much less than the length of the prothorax; ventral line of body often convex but never forming a prominent angle.

b. Thorax with a strongly carinate median ridge, highest at the middle of the mesothorax, and forming a prominent projection; ab-

domen with a lateral carinate ridge on each side, forming two prominent projections on the second and third segments, the latter more prominent; a median carinate ridge from the fourth abdominal segment to the caudal end of the body; ventral line of body practically straight.................... *Pontia* Fabricius.

bb. Thorax without a strongly carinate median ridge, either without a median ridge or with one of equal height throughout.

c. Ventral surface of body convex, but without any prominent rounded projection; a low lateral ridge present along the wings, extending on the abdomen to the caudal end of the body. *Eurymus* Swainson.

cc. Ventral surface of body produced into a prominent rounded projection which, near the caudal margin of the wings, is as wide as the body just caudad of the wings; body without any prominent ridges, a lateral ridge present along the wings but scarcely indicated on any of the abdominal segments except the tenth .... *Eurema* Hübner.

aa. Distance from the cephalic margin of the prothorax to the distal end of the cephalic projection about equal in length to the thorax; ventral line of body forming a prominent obtuse angle at a point about equidistant from the cephalic and caudal ends. .*Synchloe* Hübner.

The following species were examined:

Pontia protodice Boisduval and Le Conte, *rapae* Linnaeus
Eurymus philodice Godart
Eurema nicippe Cramer
Synchloe genutia Fabricius

Family Nymphalidae

The members of this family have been variously subdivided. Some writers make several families of the species included here, while others divide them into subfamilies and tribes. At present no good characters are known for the division of this group into families, but it must be admitted that the same difficulties lie in the way of dividing it into the subfamilies and tribes proposed by Scudder; consequently, several subfamily names have been introduced here to facilitate the grouping of the species. The Nymphalidae are distinguished from all other families lacking the epicranial suture by the fact that both prothoracic and mesothoracic legs extend cephalad to the eye-pieces and the mesothoracic legs extend for a short distance between the sculptured eye-pieces and the antennae. The prothoracic legs are very short, rarely more than one third the length of the wings. The antennae and maxillae, except in a few instances, reach to the caudal margin of the

wings. The proximal ends of the antennae extend almost to the meson on the dorsum of the head. The labial palpi are represented by a very small portion caudad of the labrum and in many cases are entirely concealed. With the exception of *Anaea andria* the metathoracic wings are not visible on the ventral surface. The genital openings are in the usual position. The circular furrow enclosing the anal opening with the small tubercles caudad of the genital openings, is present in nearly all genera. When tubercles are present on the surface of the body they are usually on the dorsum of the abdomen and are arranged in seven rows, as follows: a dorso-mesal row (Fig. 81, dmt), a dorso-lateral row on each side about half-way between the meson and the spiracles (Fig. 81, dlt), and a dorsal (Fig. 81, dst), and ventral row (Fig. 81, vst) on each side of the abdominal spiracles. The subfamilies of Nymphalidae may be separated as follows:

a. With prominent tubercles on the dorsal surface of the body, or at least on the abdomen, a dorso-mesal row, a dorso-lateral row on each side, and a row dorsad and ventrad of each row of spiracles. NYMPHALINAE.

aa. Without prominent tubercles on the dorsal surface, at least not arranged in rows as above.

b. Second abdominal segment with a prominent carinate median elevation, somewhat constricted at its base......BASILARCHINAE.

bb. Second abdominal segment without a prominent, carinate median elevation.

c. Body compressed, with a distinct dorso-mesal carina on the thorax and abdomen; ventral surface of ninth and tenth abdominal segments with hooked setae, the tubercles on the ninth segment covered with very short hooked setae....APATURINAE.

cc. Body not compressed; dorso-mesal carina never present on both thorax and abdomen.

d. Abdominal segments caudad of the wings rapidly tapering and forming a sort of hemisphere; dorsum of abdomen with a prominent transverse ridge.

e. Head with a prominent transverse ridge, extending along the middle of the eye-pieces and the lateral margin of the body; second, third, and fourth abdominal segments of approximately the same length; cremaster directed ventrad; transverse ridge on the fourth abdominal segment. ANAEINAE.

ee. Head without a transverse ridge, but with two prominent tubercles; second abdominal segment longer than any of the others; cremaster directed caudad; transverse ridge on the third abdominal segment tuberculate for its entire length ....EUPLOEINAE.

dd. Abdominal segments caudad of the wings not rapidly tapering to form a hemisphere; dorsum of abdomen never with a transverse ridge.

e. Mesothorax prominently elevated; head with a transverse ridge forming slightly produced cephalo-lateral angles; cremaster with hooked setae.................SATYRINAE.

ee. Mesothorax not prominently elevated; head never with a tranverse ridge; caudal end of body without hooked setae; cremaster never present ....OENEINAE.

Subfamily *Nymphalinae*

This subfamily includes all the genera with prominent tubercles on the surface of the body. There are usually seven rows of these, mostly on the dorsal surface of the abdomen, as follows: a dorso-mesal row; on each side of this a dorso-lateral row; and a row dorsad and ventrad of the abdominal spiracles on each side (Fig. 81). The majority of species have a cephalo-lateral projection on each side of the head; in some these are very prominent; in others, reduced to small rounded tubercles or wanting. The body is usually strongly convex near the caudal margin of the wings on the ventral surface, and the cremaster is curved ventrad. The cremaster is more prominent in this subfamily than in the family Papilionidae and bears a mass of short hooked setae at its distal end. The species of Nymphalinae have been grouped into three tribes, mostly according to the size and arrangement of the tubercles. These three tribes may be separated as follows:

a. Dorso-mesal tubercles smaller than those of the dorso-lateral rows; cremaster never with prominent lateral projections at the base.

b. Cremaster longer than broad; dorso-mesal tubercles always present on abdominal segments 3–8 and usually on the second segment ....VANESSINI.

bb. Cremaster usually broader than long; dorso-mesal tubercles often wanting and never present cephalad of the fourth segment. ARGYNNINI.

aa. Dorso-mesal tubercles equal in size to those of the dorso-lateral rows; cremaster always with a lateral projection on each side at the base. MELITAEINI.

TRIBE VANESSINI

This tribe includes the species with all the rows of tubercles represented and most of them complete. The tubercles of the dorso-mesal row are considerably smaller than those of the dorso-lateral row, which are usually very prominent. The rows of tubercles on either

side of the spiracles are always very small. The cremaster is long and never has prominent lateral tubercles at its proximal end. The genera of Vanessini may be separated by the following table:

a. Cephalic prominences conical, with length and breadth approximately equal; dorso-lateral tubercles on the fourth abdominal segment always larger than the others.
  b. Dorso-lateral tubercles on abdominal segments 2–7 long and sharp, spine-like, the length considerably greater than the breadth; dorso-mesal tubercle absent on the second abdominal segment. *Euvanessa* Scudder.
  bb. Dorso-lateral tubercles on abdominal segments 2–7 not sharp and spine-like; the length scarcely, if any, greater than the breadth; dorso-mesal tubercle present on the second abdominal segment.
    c. Dorso-lateral tubercles on fourth abdominal segment at least twice the size of the others; median elevation of the mesothorax a compressed carinate ridge and usually very prominent. *Polygonia* Hübner.
    cc. Dorso-lateral tubercles on fourth abdominal segment very little larger than the others; median elevation of the mesothorax pyramidal and not very prominent.......... *Aglais* Dalman.
aa. Cephalic prominences usually blunt, the length less than the breadth; dorso-lateral tubercles on the fourth abdominal segment never larger than the others.
  b. Cephalic prominences broadly rounded; scarcely elevated beyond the outline of the body; no distinct prominence on the median line of the mesothorax...................... *Junonia* Hübner.
  bb. Cephalic prominences distinctly elevated beyond the outline of the body; a distinct prominence on the median line of the mesothorax .... *Vanessa* Fabricius.

The following species were examined:

Euvanessa antiopa Linnaeus
Polygonia interrogationis Fabricius, *comma* Harris, *faunus* Edwards, *progne* Cramer
Aglais milberti Godart
Junonia coenia Hübner
Vanessa atalanta Linnaeus, *huntera* Fabricius, *cardui* Linnaeus

Tribe ARGYNNINI

The species included here resemble those of the preceding tribe, excepting that the dorso-mesal row of tubercles is only present on a few segments or is entirely wanting. The cremaster is short and broad and never has a prominent projection on each side at the proximal end. The genera of Argynnini may be separated by the following table:

a. Dorso-lateral row of tubercles of approximately equal size.
  b. Dorso-mesal row of tubercles present on abdominal segments 4–7; dorso-lateral tubercles much larger than the stigmatal rows; carinate ridge present on mesothorax..........*Argynnis* Fabricius.
  bb. Dorso-mesal row of tubercles absent on all segments; dorso-lateral tubercles about equal in size to the dorsal stigmatal row; mesothorax without a carinate ridge.....*Euptoieta* Doubleday.
aa. Dorso-lateral row of tubercles of different sizes, the largest on the third abdominal segment.
  b. Body with a very strong ventral curve opposite the third and fourth abdominal segments; mesothorax with a strongly elevated median ridge throughout its length; head projections very prominent, irregularly bilobed.
Agraulis Boisduval and Le Conte.
  bb. Body without a strong ventral curve; mesothorax with a small ridge on the caudal half; head projections short, pointed.
Brenthis Hübner.

The following species were examined:
Argynnis cybele Fabricius
Euptoieta claudia Cramer
Agraulis vanillae Linnaeus
Brenthis myrina Cramer

Tribe MELITAEINI

The species in this group have the dorso-mesal and dorso-lateral tubercles of approximately equal size, but none of them are very large and they are usually rounded. The cremaster always has a prominent projection on each side at its proximal end. The genera of Melitaeini may be separated as follows:

a. Tubercles of the dorsal spiracular row not present on the second abdominal segment; no tubercles present on the eighth abdominal segment.
  b. Dorsum of abdomen with a distinct tranverse ridge on the fourth segment; dorsal spiracular row of tubercles not distinct on any of the segments ....*Phyciodes* Hübner.
  bb. Dorsum of abdomen without a transverse ridge on the fourth segment; dorsal spiracular row of tubercles very large on the third and fourth abdominal segments ....*Charidryas* Scudder.
aa. Tubercles of the dorsal spiracular row present on the second abdominal segment; tubercles present on the eighth abdominal segment.
  b. Tubercles of the eighth abdominal segment nearly as large as the others, the abdominal tubercles all broadly rounded and never longer than broad; cremaster with a deep depression on the dorsal surface and a circular depression on the ventral surface, the lateral tubercles very prominent, rounded, smooth and polished.
Euphydryas Scudder.

bb. Tubercles of the eighth abdominal segment much smaller than the others, the abdominal tubercles all somewhat pointed and longer than broad; cremaster never with a deep depression on the dorsal surface, but with a long narrow furrow on the ventral surface, the lateral tubercles somewhat triangular in outline and slightly rugose like the cremaster...........*Cinclidia* Hübner.

The following species were examined:
Phyciodes tharos Drury
Charidryas nycteis Doubleday and Hewitson
Euphydryas phaeton Drury
Cinclidia harrisii Scudder

Subfamily *Basilarchinae*

The genus Basilarchia differs from all the genera of Nymphalinae, with which it is generally included, on account of the absence of the rows of tubercles. There are two cephalic projections, as in many Nymphalinae, and on the dorsum of the second abdominal segment there is a very large carinate projection. This is somewhat oval in outline as seen in lateral view, being constricted at the base. The body is not prominently excurved in the region of the appendages as in the Nymphalinae, but is of the same general shape. It agrees with the Nymphalinae only in the characters common to all members of the subfamily and is therefore placed in a separate subfamily.

The following species were examined:
Basilarchia astyanax Fabricius, *arthemis* Drury, *archippus* Cramer.

Subfamily *Apaturinae*

The species of this subfamily, included by Scudder in the Nymphalinae, show no characters which unite them with that subfamily. The group, according to Scudder, included the genera Chlorippe and Anaea, which differ so widely in the pupae that they could not well be combined in the same subfamily. The name Apaturinae has been retained for the genus Chlorippe. These pupae are strongly compressed, with a prominent median dorsal carinate ridge. There are two cephalic projections and the ventral surface of the body forms a straight line while the dorsum is strongly arched. The antennae are slightly elevated and tuberculate. The genital openings are sunken and almost concealed. On either side of the anal opening near its cephalic end there is a small tubercle covered with hooked setae. The cremaster is short and triangular, and the hooked setae are nearly all on the ventral surface.

The following species were examined:
Chlorippe celtis Boisduval and Le Conte, *clyton* Boisduval and Le Conte.

Subfamily *Anaeinae*

This subfamily includes a single genus, Anaea, which was included with Chlorippe in the tribe Apaturini by Scudder. The pupae are so different, however, that they have in common only the ordinary nymphalid characters. The body is never compressed, but the abdominal segments caudad of the wings taper very rapidly and form a hemisphere. The long cremaster is inserted near the center of the hemisphere and curves ventrad. The fourth segment has a prominent transverse ridge. The ventral surface of the abdominal segments caudad of the wings is very short and the genital openings are concealed. The head has a prominent transverse ridge at the cephalic end which extends caudad through the middle of the eye-pieces and along the lateral margin of the body. The metathorax has a rather prominent rounded ridge on the meson. The antennae and maxillae extend to the caudal margin of the wings.

The following species was examined:
Anaea andria Scudder.

Subfamily *Euploeinae*

This subfamily is equivalent to the family Lymnadidae of some authors. It includes two genera, of which only Anosia has been examined. The general shape of the body is very like that of the genus Anaea of the subfamily Anaeinae, but it has the second abdominal segment very long, as well as the thorax, and the cremaster extends caudad. There is never a ridge on the head, but it has a tubercle at each cephalo-lateral margin. The transverse ridge is on the third segment and is tuberculate. The maxillae do not reach the caudal margin of the wings in Anosia and the antennae lie adjacent on the meson caudad of them.

The following species was examined:
Anosia plexippus Linnaeus.

Subfamily *Satyrinae*

The Satyrinae are similar in shape to the Nymphalinae, but have no tubercles on the surface of the body and but few prominent ridges. The head always has a prominent transverse ridge at the cephalic end, and this often forms slight cephalo-lateral angles. There is also a slightly carinate ridge at each lateral margin of the body extending

as far caudad as the second abdominal segment. The metathorax always has a median elevation, which sometimes forms a prominent angle. The circular ridge surrounding the anal opening is not strongly elevated but the tubercles are prominent on each side of the genital opening on the ninth segment. The genera of this subfamily may be separated by the following table:

a. Cremaster broader than long, with hooked setae present on the ventral surface; genital opening never with a tubercle on each side. *Cissia* Doubleday.

aa. Cremaster longer than broad, the hooks always inserted at the distal end, never on the ventral surface; genital opening always with a distinct tubercle on each side.

b. Mesothoracic elevation rounded; cremaster concave at tip with the hooked setae inserted in the hollow; body surface with fine indeterminate striations ....*Cercyonis* Speyer.

bb. Mesothoracic elevation with a distinct angle; cremaster not concave at tip; body surface smooth..........*Satyrodes* Scudder.

The following species were examined:
Cissia eurytus Fabricius
Cercyonis alope Fabricius
Satyrodes canthus Linnaeus

Subfamily *Oeneinae*

The genus Oeneis has none of the distinguishing characters of the subfamily Satyrinae and therefore is not here included with the members of that group. The body has the general shape of a lycaenid, and the segments seem as devoid of motion (Fig. 80). In other respects it is a typical nymphalid. The antennae do not quite reach the caudal margin of the wings, and overlie the maxillae at their distal end, so that the antennae are adjacent on the meson. Their proximal ends are very near the meson on the dorsal surface of the head. There is no distinct ridge surrounding the anal opening, nor are any tubercles present caudad of the genital openings. There is no cremaster, nor hooked setae at the caudal end of the body.

Only one species was examined:
Oeneis semidea Say.

Specialized pupae without pilifers

This division includes the remaining superfamilies of Lepidoptera. The seventh abdominal segment is fixed in both sexes in all the families except the Epermeniidae, in which this segment is fixed in the

male. None of the species included here have dorsal movement between any of the segments cephalad of the fourth. In this they differ from the superfamilies Pyralidoidea and Papilionoidea, some members of which retain dorsal movement of the third abdominal segment. This group includes all the most specialized families. The origin of most of these is doubtful. The Noctuoidea show the strongest relationship to the Pyralidoidea; the Notodontoidea, to the Gelechioidea. All the evidence at present points to the fact that the Pyralidoidea and Gelechioidea have descended from a common ancestor closely allied to the Yponomeutoidea. The Sphingoidea and Saturnioidea, which show considerable relationship to each other, seem to have arisen from a common stem with the more generalized Bombycoidea, which in turn seem nearly related to the Noctuoidea and Notodontoidea.

Superfamily YPONOMEUTOIDEA

The families included here show well-developed labial palpi, and have a large portion of the prothoracic femora exposed. All show the maxillary palpi except the Coleophoridae, and the same arrangement of parts prevails throughout the superfamily. The epicranial suture is present in all families. The prothorax is always very short on the meson, but much longer on each lateral margin so that each half is triangular. The appendages always reach beyond the caudal margin of the fourth segment, and in some cases are almost as long as the body. They are soldered firmly to each other but are free from the body wall. Abdominal segments 1–4 are longer than any of the others. There are usually spines or setae present at the caudal end of the body but seldom a cremaster. The pupae are usually less than 10 mm. in length. The families may be separated by the following table:

a. Cremaster present, but short, with hooked setae at the distal end; ninth abdominal segment with a deep lateral cavity on each side; seventh abdominal segment free in the male.........EPERMENIIDAE.

aa. Cremaster absent; ninth abdominal segment never with a deep lateral cavity; seventh abdominal segment fixed in both sexes.

  b. Maxillary palpi present; caudal end of body without lateral prolongations ending in spines..................YPONOMEUTIDAE.

  bb. Maxillary palpi never present; caudal end of body with lateral prolongations ending in sharp spines.........COLEOPHORIDAE.

Family EPERMENIIDAE

This family, which has usually been combined with the Elachistidae, or, by some writers, with the Scythridae, is here associated with

the Yponomeutidae, the only important differences between the two families being the freedom of the seventh abdominal segment in the male and the presence of a very short cremaster in the Epermeniidae. Another difference is that in Epermeniidae the wings and other appendages are somewhat elevated at the meson and slope to each lateral margin. A comparison of Figure 68 with Figures 82, 83, and 85 will show the similarity in arrangement of parts in the Yponomeutidae and Epermeniidae.

The following species was examined:
Epermenia pimpinella Murtfeldt.

Family Yponomeutidae

The genera comprising this family resemble each other very strongly in all important characteristics, but nevertheless possess very clear generic distinctions. They closely resemble certain of the generalized gelechiids (Figs. 88, 89), and many authors have associated those genera with the yponomeutids. The presence of a distinct fronto-clypeal suture and the peculiar arrangement of the antennae in the family Gelechiidae, together with the apparent loss of the labial palpi, seem to separate it very clearly from the Yponomeutidae, in which the fronto-clypeal suture is never distinct and the antennae are never adjacent on the meson except in Zelleria (Fig. 82). The typical arrangement of parts is seen in Figures 82, 83, 84, 85, 86, making further description unnecessary. The abdominal spiracles are all considerably produced and tubular, being longest in Plutella. There is no cremaster present in any of the genera. The genera of Yponomeutidae may be separated by the following table:

a. Mesothoracic spiracles produced, tube-like; setae at caudal end of tenth segment hooked; maxillae more than three fourths the length of the wings .... *Plutella* Schrank.

aa. Mesothoracic spiracles not produced, slit-like; setae at caudal end of tenth segment straight, or occasionally slightly curved at end; maxillae much less than three fourths the length of the wings.

b. Caudal end of tenth segment showing four straight setae, generally two directed laterad and two caudad; maxillary palpi touched by both prothoracic and mesothoracic legs.

c. Maxillary palpi long, reaching the proximo-lateral angles of the maxillae; labial palpi never becoming wider than at their proximal margin; antennae never touching on the meson. *Yponomeuta* Latreille.

cc. Maxillary palpi short, never reaching the proximo-lateral angles of the maxillae; labial palpi wider through most of their length than at the proximal margin; antennae touching on the meson. *Zelleria* Stainton.

bb. Caudal end of tenth segment showing eight setae; four of these on the ventral surface extending laterad and sometimes slightly curved at the tip; mesothoracic legs never reaching cephalad to the maxillary palpi .... *Argyresthia* Hübner.

The following species were examined:
Plutella maculipennis Curtis
Yponomeuta padellus Linnaeus, *malinellus* Zeller
Zelleria celastrusella Kearfott
Argyresthia freyella Walsingham

Family Coleophoridae

This family has usually been associated with the Elachistidae, but since the division of that family the name means very little unless we use it to include the genus Elachista and others closely related, which certainly would not include the Coleophoridae. They seem, rather to be more closely allied to the Yponomeutidae and are so considered here. They differ mainly in the loss of the maxillary palpi and in the lateral extensions of the ninth abdominal segment (Fig. 87). The appendages are usually very long, extending nearly to the caudal margin of the body, and often beyond it, when the movable segments are contracted. The abdominal segments from the first to the sixth are very much longer than the remaining segments.

The following species were examined:
Coleophora caryaefoliella Clemens, *vernoniaeella* Chambers, *malivorella* Riley.

Superfamily GELECHIOIDEA

This superfamily includes those pupae which possess a distinct epicranial suture, with the caudal portions of the antennae lying adjacent on the meson and usually separating at their distal ends to expose the metathoraic legs. The maxillary palpi are usually present, but labial palpi and prothoracic femora are seldom exposed. The body is usually ovate in outline as seen in dorsal or ventral view; widest in the thoracic region and somewhat depressed. The superfamily is closely related to the Yponomeutoidea. It includes here two groups representing two distinct lines of development: the group retaining the fronto-clypeal suture, including the families Lavernidae, Scythridae, Gelechiidae, and Chrysopeleiidae; and those in which it is not distinct or is absent, including the families Oecophoridae, Stenomidae, Cosmopterygidae, and Elachistidae. The latter group may represent a distinct superfamily when all its allied genera have been studied, but at present there is no evidence to warrant such a conclusion. The following table will serve to separate the families of Gelechioidea:

a. Fronto-clypeal suture always distinct for its entire length, sometimes forming a prominent curve or angle at the meson.
  b. Labial palpi exposed for their entire length.
    c. Femora of the prothoracic legs visible; maxillary palpi either reaching the proximo-lateral angles of the maxillae or approaching them very closely; tenth abdominal segment with stout spines at the caudal end........................LAVERNIDAE.
    cc. Femora of the prothoracic legs never visible; maxillary palpi minute; tenth abdominal segment with hooked setae at the caudal end ....SCYTHRIDAE.
  bb. Labial palpi never exposed for their entire length, usually concealed.
    c. Maxillary palpi present and usually reaching the proximo-lateral angles of the maxillae; antennae usually adjacent on the meson for the caudal two fifths of their length, separating at distal ends to show the metathoracic legs............GELECHIIDAE.
    cc. Maxillary palpi never present; antennae adjacent on the meson for the caudal two fifths of their length but not separated at their distal ends .......................CHRYSOPELEIIDAE.
aa. Fronto-clypeal suture never distinct for its entire length and never reaching the meson.
  b. Abdominal segments 4–6 movable, with very deep incisions between the segments on the dorsal and ventral surfaces; body depressed.
    c. Maxillary palpi large,. usually reaching the proximo-lateral angles of the maxillae; hooked setae never present on the ventral surface of the ninth abdominal segment.....OECOPHORIDAE.
    cc. Maxillary palpi minute; hooked setae always present on the ventral surface of the ninth abdominal segment.....STENOMIDAE.
  bb. Abdominal segments 4–6 never all movable; incisions between the segments of equal depth on all surfaces; body not depressed.
    c. Maxillary palpi present; sixth abdominal segment movable. COSMOPTERYGIDAE.
    cc. Maxillary palpi absent; no abdominal segments movable. ELACHISTIDAE.

Family LAVERNIDAE

The pupae belonging to this family are more generalized than any other members of the superfamily and closely resemble pupae belonging to the family Yponomeutidae. They have been included here on account of the distinct fronto-clypeal suture, present in all except the more specialized Gelechioidea, and also because the prothorax, which is so short on the meson in Yponomeutidae with each half triangular in outline, in this family loses that condition and becomes almost as long on the meson as at the lateral margins, so that each half is sub-

quadrangular. This is the only family of Gelechioidea which retains both labial palpi and exposed portions of the prothoracic femora. The appendages have the characteristic arrangement of the superfamily (Fig. 88) except that the antennae do not separate near their distal end to expose a portion of the metathoracic legs, but these are seen caudad of the antennae adjacent on the meson. The wings are long and pointed in Lophoptilus, but rounded in Laverna. The first four abdominal segments are longer than the remaining caudal segments in this family, and the appendages are soldered to them, but are free for the remainder of their length. This family has been considered as a subfamily of Elachistidae by most authors, and has usually included Cosmopteryx, which is a much more specialized genus. The following table will serve to separate the genera of Lavernidae:

a. Head long, somewhat pointed, the length more than half the greatest width; fronto-clypeal suture making an acute angle at meson; spines of the tenth segment extending dorsad and not visible in ventral view; exposed part of metathoracic leg about one fifth the length of the portion of the antennae lying adjacent on the meson. *Lophoptilus* Sircom.

aa. Head short, blunt, the length about equal to half the greatest width; fronto-clypeal suture making an obtuse angle at meson; spines of tenth segment extending laterad and visible in ventral view; exposed part of metathoracic leg about equal in length to the portion of the antennae lying adjacent on the meson......*Laverna* Curtis.

Family Scythridae

The pupae of this family also resemble the Yponomeutidae in some respects, and have been included with them by some authors. Others have associated the family with the Elachistidae, while Stainton included it with the Gelechiidae as the genus Butalis. The antennae in this family meet on the meson, but do not separate to show the distal ends of the metathoracic legs as is the general rule in this superfamily. Instead, the mesothoracic wings lie adjacent on the meson caudad of the antennae, and the appendages are firmly soldered to each other and to the body (Fig. 89). As the appendages extend caudad for about half the length of the seventh abdominal segment, it follows that there can be no motion possible between any of the abdominal segments, unless there be slight dorsal motion. The prothorax is typically gelechiid in character. The abdominal spiracles are considerably produced and tubular, their length varying in the different species. The setae of the body are nearly all hooked, and a few longer ones are pres-

ent at the caudal end of the body. Only one genus of this family was available for study.

The following species were examined:
Scythris eboracencis Zeller, *impositella* Zeller.

Family Gelechiidae

The pupae of the Gelechiidae never show any portion of the labial palpi, unless it should be a very small triangular area caudad of the labrum, between the halves of the maxillae. The prothoracic femora are never exposed (Figs. 90, 91, 92, 93, 94). The fronto-clypeal suture is always distinct and usually extends almost straight across between the proximal ends of the antennae, but occasionally each half is directed cephalad near the meson so that an angle is formed at their junction. The caudal parts of the antennae usually lie adjacent on the meson for about two fifths of their length and usually cover the caudal ends of the maxillae and sometimes of the prothoracic and mesothoracic legs. They usually separate at their distal ends to show the metathoracic legs, or what will be referred to as such in this paper. There was not enough available material in condition for dissection to determine whether the maxillae ever reached the caudal margin of the wings and overlaid the metathoracic legs, as might easily be the case. The maxillary palpi are present in all, but do not always reach the proximo-lateral angles of the maxillae. They are always reached by both prothoracic and mesothoracic legs. The wings vary somewhat in length, but are usually firmly soldered down, and the abdominal segments are somewhat depressed on the ventral surface, forming a shallow cavity into which the wings are fitted and, therefore, are not elevated above the surface of the body. There are usually very deep incisions between the segments, especially on the dorsal and ventral surfaces. Many species have the incisions deeper on the ventral surface so that the caudal end of the body may be strongly curved ventrad. The pupae are usually very active, and many of them are able to move after the fashion of click-beetles. The body is entirely covered with setae in some genera, while others have a fringe of setae along the margin of certain slightly projecting ridges and occasional depressions found usually on the seventh abdominal segment. There seems doubt as to the generic standing of the following species: *Aristotelia physaliella*, *Gnorimoschema lavernella*, and *Recurvaria variella*; at least they differ from other species examined in these genera. In the case of *Aristotelia* it has been impossible to determine which species is the type of the genus. The genera of Gelechiidae may be separated as follows:

a. Body setae very long and heavily chitinized, often as long as the segments of the abdomen, and, as seen under high power, usually forked at the apex; fronto-clypeal suture curving cephalad from the proximal ends of the antennae to the cephalic margin of the body; cremaster always present; dorsal cephalic margin of segments two, three, and four of the abdomen with a slight rounded projection on each side of the meson, edged with a dense fringe of whitish setae directed cephalad, caudad of this a prominent elevation bearing a similar fringe of setae on the summit (Fig. 91).

b. Dorsal surface of the cephalic margin of the movable segments with a prominent cavity on the meson having heavily chitinized edges ....*Trichotaphe* Clemens.

bb. Dorsal surface of cephalic margin of the movable segments without any cavity; a strongly chitinized ridge separating the cephalic margin from the remainder of the segment, cephalad of this a band of short spines, then a prominent furrow, the furrow and the remainder of the cephalic margin being deeply punctate. *Ypsolophus* Fabricius.

aa. Body setae never modified; segments two, three, and four of the abdomen never as described in a.

b. Entire body with a dense covering of whitish setae visible to the unaided eye, giving the pupa a furred appearance.

c. Maxillary palpi long, reaching the proximo-lateral angles of the maxillae; antennae lying adjacent on the meson for about two fifths of their length; cremaster short and blunt, the end set with about eight stout curved setae; length 8–10 mm. *Anacampsis* Curtis.

cc. Maxillary palpi short, never reaching the proximo-lateral angles of the maxillae; antennae just meeting on the meson; cremaster with a sharp point curved dorsad, with curved setae at the sides and base; length 5–6 mm. ....*Aristotelia* (a) Hübner.

bb. Entire body never covered with setae.

c. Seventh abdominal segment with a dense fringe of setae on some portion.

d. Fringe of setae confined to the cephalic and lateral edges of a prominent lateral cavity.

e. Body smooth, not depressed; cephalic edge of the lateral cavity trilobed (Fig. 93) ....*Evippe* Chambers.

ee. Body with small spines, strongly depressed; cephalic edge of the lateral cavity bilobed ....*Telphusa* Chambers.

dd. Fringe extending around the segment or nearly so.

e. Fringe extending around the segment in a straight line; body not noticeably depressed, the surface smooth. *Recurvaria* (a) Haworth.

ee. Fringe extending around the segment in a more or less wavy line; body noticeably depressed and very broad in the thoracic region, surface with punctures or spines.

f. Abdominal segments 8–10 distinctly tapering to the caudal end of the body; fringe of seventh segment extending in a wavy line around the body and edging two very large lobes on the dorsal surface.
Trypanisma Clemens.

ff. Abdominal segments 8–10 not tapering but blunt and slightly rounded at the caudal end of the body; fringe extending in a wavy line around the seventh segment, without prominent lobes on the dorsal surface.
Gelechia Hübner.

cc. Seventh abdominal segment without any fringe of setae.

d. Caudal end of body with short, stout projecting spines.

e. Caudal end of body with one such spine on the dorso-meson, projecting dorsad; fronto-clypeal suture almost straight.
Phthorimaea Meyrick.

ee. Caudal end of body with a median spine and one on each lateral margin; fronto-clypeal suture extending cephalad from the base of each antenna to the cephalic margin of the head .... *Sitotroga* Heinemann.

dd. Caudal end of body with straight or curved setae.

e. Hooked setae present at the caudal end of the body.

f. Antennae reaching the caudal margin of the wings, their caudal ends separated to show the metathoracic legs.

g. Caudal end of body with at least five long hooked setae on each side of the meson; antennae slightly enlarged at their proximal ends, making the cephalic end of the body somewhat truncate..... *Recurvaria* (b) Haworth.

gg. Caudal end of body never with more than two long curved setae on each side of the meson; cephalic end of body rounded............ *Aristotelia* (b) Hübner.

ff. Antennae never reaching the caudal margin of the wings nor separating at their caudal ends to expose the metathoracic legs .... *Gnorimoschema* (a) Busck.

ee. Hooked setae never present at the caudal end of the body; a few short, straight setae present.
Gnorimoschema (b) Busck.

The following species were examined:

Trichotaphe flavocostella Clemens
Ypsolophus citrifoliellus Chambers, *eupatoriellus* Chambers
Anacampsis sp., *rhoifructella* Clemens
Aristotelia (a) *salicifungiella* Clemens
Aristotelia (b) *physaliella* Chambers
Evippe prunifoliella Chambers
Telphusa quercinigracella Chambers, *pallidcrosacella* Chambers

Recurvaria (a) *apicitripunctella* Clemens
Recurvaria (b) *variella* Chambers
Trypanisma prudens Clemens
Gelechia cerceriseIla Chambers, *discoocellella* Chambers, *serotinella* Busck
Phthorimaea sp.
Sitotroga cerealella Olivier
Gnorimoschema (a) *lavernella* Chambers
Gnorimoschema (b) *gallaesolidaginis* Riley

Family Chrysopeleiidae

This family includes the genus Chrysopeleia which was formerly included with the Elachistidae. It has the same arrangement of parts as that in the genus Elachista but retains the fronto-clypeal suture and has no cremaster (Fig. 95). Until more is known of the relationships of this genus it seems better to place it in a family by itself. The appendages are slightly elevated and firmly soldered to each other and to the body. They extend well on to the seventh abdominal segment, so that there appears to be no motion possible between any of the body segments. There is no cremaster present and only a few short straight setae at the caudal end of the body. The abdominal spiracles are produced and tubular. The pupae are very small, being only about 3 mm. in length.

The following species was examined:
Chrysopeleia ostryaeella Chambers.

Family Oecophoridae

This family (Figs. 97 and 98) includes those pupae in which the fronto-clypeal suture is not present for its entire length and which have large maxillary palpi, usually reaching the proximo-lateral angles of the maxillae. All the species examined showed the presence of very fine setae arranged in groups over the surface of the abdomen, but these were hard to locate in Psilocorsis. The incisions between the segments are very deep in all members of the family. Of the three genera studied Psilocorsis, Agonopteryx, and Depressaria, the first seemed more nearly related to the Stenomidae, while the other two were typical gelechiids, except that the fronto-clypeal suture was never distinct. It seems probable that a revision of the group might separate these genera. The table to genera will indicate the principal differences. The body is usually strongly depressed and 5–10 mm. in length. The following table will serve to separate the genera:

a. Femora of the prothoracic legs exposed.
  b. Wings pointed, extending on to the sixth abdominal segment; proximal end of each antenna elevated and roughened with transverse ridges; cremaster present............*Psilocorsis* Clemens.
  bb. Wings not pointed, and never extending beyond the caudal margin of the fourth abdominal segment; proximal end of each antenna never elevated or roughened with transverse ridges; cremaster never present ....*Depressaria* Haworth.
aa. Prothoracic femora never exposed...........*Agonopteryx* Hübner.

The following species were examined:
Psilocorsis obsoletella Zeller, *quercicella* Clemens
Depressaria heracliana De Geer
Agonopteryx nebulosa Zeller

Family Stenomidae

The Stenomidae include most of the genera formerly grouped under the name of Xylorictidae. The appendages are arranged as in the Gelechiidae and the maxillary palpi are minute (Fig. 96). A small portion of the labial palpi is usually apparent. The appendages are firmly soldered to each other and to the body wall. They extend slightly beyond the caudal margin of the fourth abdominal segment, so that there are three free segments, the fourth, fifth, and sixth. The margins of these free segments are serrate along the edges of the incisions, which are very deep, especially on the ventral surface, and permit the caudal end of the body to be very sharply curved ventrad, reaching almost to the caudal margin of the wings (Fig. 96a). The fronto-clypeal suture is visible for a short distance mesad of the proximal end of each antenna, but it never reaches the meson. There are many curved setae present on the ventral surface of the ninth abdominal segment. The body is always more or less depressed, and in Stenoma is about 8 mm. in length, in Menesta 3 mm. The genus Menesta, formerly included in the Gelechiidae, seems more closely allied to Stenoma and is included here. Stenoma possesses peculiarly modified setae on the body surface. These genera may be separated as follows:

a. Antennae modified at their proximal ends, forming an enlarged corrugated area; hooked setae on the ventral part of the ninth abdominal segment never on a distinct prolongation......*Stenoma* Zeller.
aa. Antennae never modified at the proximal end; hooked setae on the ventral part of the ninth abdominal segment on a distinct prolongation ....*Menesta* Clemens.

The following species were examined:
Stenoma schlaegeri Zeller
Menesta albaciliaeella Chambers

Family Cosmopterygidae

This family name as used by most authors is equivalent to Lavernidae or Momphidae, and the genera included under all these names are usually associated with each other. The Cosmopterygidae are much more specialized, however, as they retain neither visible labial palpi nor prothoracic femora (Fig. 99). The appendages are firmly soldered to each other and to the body wall as far as the caudal margin of the sixth abdominal segment, which allows freedom of movement to this segment. There are some generalized characters present, however—the length of the first six abdominal segments, which are as long as in Yponomeutidae, and the shape of the prothorax, which is shorter on the meson than at each lateral margin. The abdominal spiracles are slightly produced and tubular. There is a very short cremaster present bearing eight hooked setae, of which four are longer than the remainder. The pupae are about 4 mm. in length.

The following species was examined:
Cosmopteryx clandestinella Busck.

Family Elachistidae

This family has been variously subdivided in the past few years, for, like the Tineidae, it included a large number of species which did not form a natural group. Some authors do not retain this family name, but as the nomenclature of the group appears to be still in a rather unsettled condition, this name is retained for the present to include the genus Elachista. The appendages are arranged as in other gelechiids, but there is no trace of maxillary palpi (Fig. 100). The surface of the body is covered with large rounded tubercles and the dorsal surface shows three distinct longitudinal elevations or ridges, one on the meson and one near each lateral margin, bearing the spiracles on the summit. The wings and other appendages are firmly soldered to each other and to the body wall, and there appear to be no free segments. The prothorax is typically gelechiid and the mesothorax shows a decided alar furrow on each side. There is a distinct cremaster present, but it shows no hooked setae. The pupae are suspended from a stem or leaf after the manner of some papilionids, with a silken girth around the body. The pupae average 3.5 mm. in length.

The following species was examined:
Elachista praelineata Braun.

Superfamily NOCTUOIDEA

This superfamily includes three families, Noctuidae, Liparidae, and Arctiidae. The Syntomidae also belong to this group, but as only one species of this family was examined and this showed no characters to separate it from the Arctiidae, the Syntomidae are not discussed as a separate family. The Noctuoidea and Bombycoidea include all the specialized families which retain labial palpi. The families of Noctuoidea may be separated thus:

a. Body seldom with setae arranged around scars of larval verrucae, if present, then the femora of the prothoracic legs exposed, or a long cremaster present bearing hooked setae at the distal end; prothoracic femora usually visible, if not, then the mesothoracic leg usually extending cephalad to the eye-pieces.................... Noctuidae.

aa. Body always with setae arranged around the scars of larval verrucae; femora of the prothoracic legs never visible.

b. Maxillae never more than two fifths the length of the wings; body setae conspicuous; labial palpi usually visible........ Liparidae.

bb. Maxillae two thirds the length of the wings, or longer; body setae inconspicuous; labial palpi seldom visible.......... Arctiidae.

Family Noctuidae

This family (Figs. 101, 102, 103), with a few exceptions, is characterized by the presence of labial palpi and of maxillae which extend to the caudal margin of the wing, or very closely approximate this length. Very many of the genera have a large portion of the prothoracic femora exposed. Those which do not show any portion of the prothoracic femora have the mesothoracic leg extending cephalad to the eye-pieces, with a few exceptions in the genera Homopyralis, Plusiodonta, and Anomis. Those lacking labial palpi have setae arranged around the scars of larval verrucae, as in the Arctiidae. They differ from the Arctiidae in having hooked setae on the cremaster, and in lacking flanged plates on the abdominal segments. Maxillary palpi are found in some members of the subfamilies Agrotinae, Cucullianae, and Hypeninae. Since there was not enough material available for study to furnish a basis for subfamily characters, the genera have been grouped as seemed best for purposes of classification. As far as possible the names of subfamilies as used by Hampson in the "Catalogue of Lepidoptera Phalaenae" have been adopted. This arrangement could not be followed throughout, however, and so it must be remembered that the subfamily names used here are adopted as a matter of convenience and do not stand for the genera which Hampson

grouped together. His generic and specific names have been adopted as far as possible. As to the phylogeny of the group, too little material has been examined to warrant a decided opinion on the subject. It seems probable, however, that most of the subfamilies discussed represent the ends of many lines of development. There are various stages of development found in all groups, and there are some members of each subfamily studied, except the Phytometrinae and Mominae, which show the epicranial suture.

The subfamilies mentioned above which retain maxillary palpi are undoubtedly the most generalized, the Mominae, which show neither labial palpi, prothoracic femora, maxillary palpi, nor an epicranial suture, are undoubtedly the most specialized, but nothing can be said with certainty as to the other groups. No attempt has been made to arrange the subfamilies in phylogenetic order either in the tables or in the discussion of subfamilies. The subfamilies of Noctuidae may be separated by the following table:

a. Prothoracic legs reaching cephalad to the eye-piece, mesothoracic legs never reaching as far cephalad; prothoracic femora usually visible.
  b. Cremaster, or caudal end of the body, with all the setae curved or hooked, never with any long straight setae.
    c. Setae of the cremaster usually all of the same size and length, either slightly curved or hooked; cremaster never with six or eight hooked setae of which the mesal ones are larger and longer than the remainder .... ACRONYCTINAE.
    cc. Setae of the cremaster or caudal end of the body usually of two sizes.
      d. Body never with scars of larval verrucae bordered with setae; labial palpi and prothoracic femora always visible.
        e. Wings and maxillae produced at meson into a distinct rounded projection extending on to the fifth abdominal segment; labrum located near the cephalic end of the body; body never heavily chitinized............ PHYTOMETRINAE.
        ee. Wings and maxillae never extending beyond the caudal margin of the fourth segment; labrum in the normal position; body always heavily chitinized....... CUCULLIANAE.
      dd. Body with rounded or oval areas bordered with setae, as in the Arctiidae, especially noticeable on the dorsum of the abdomen and in the spiracular region; labial palpi and prothoracic femora never visible .... MOMINAE.
  bb. Cremaster or caudal end of the body never with all the setae curved or hooked.
    c. Cremaster or caudal end of body with at least two long straight stout setae, 1–2 mm. in length, rarely with additional hooked setae .... HADENINAE.

cc. Cremaster or caudal end of body never with long straight stout setae.

d. Cremaster bifurcate, narrowed at the caudal end; dorsum of movable abdominal segments with one or more rows of deep circular pits with dark, chitinized margins...... AGROTINAE.

dd. Cremaster short, broader at the distal end, very thin and plate-like, the caudo-lateral angles produced into short rounded lobes, with two or three small rounded projections between often bearing small delicate setae; dorsum of the movable abdominal segments never with pits; body strongly rugose, the abdominal segments spinose...... AGARISTINAE.

aa. Prothoracic and mesothoracic legs both reaching cephalad to the eye-piece or to the maxillary palpus where this is present; prothoracic femora seldom visible.

b. Cremaster usually present; curved or hooked setae always present at the caudal end of body, usually eight in number.

c. Body always covered with a whitish bloom........ CATOCALINAE.

cc. Body never covered with a whitish bloom.......... HYPENINAE.

bb. Cremaster or setae never present at the caudal end of the body; fifth abdominal segment with a row of spines along the caudal margin extending from the sculpturing of the dorsum almost to the meson on the ventral surface .... SARROTHRIPINAE.

Subfamily *Agrotinae*

This subfamily, as here considered, includes those pupae with a stout, rugose, more or less bifurcate cremaster, and with a row of large circular pits with heavily chitinized margins along the cephalic margin of some of the abdominal segments, usually between the fourth and seventh (Fig. 101). In these pupae, the prothorax is very long, at least two thirds the length of the mesothorax, and the epicranial suture is sometimes present in the genus Agrotis. Labial palpi are always present and exposed for their entire length, and the prothoracic femora are seen in some of the genera. The mesothoracic legs, antennae, and maxillae are of practically the same length and usually extend to the caudal margin of the wings. The metathoracic legs are seldom visible and only the prothoracic legs extend cephalad to the eye-pieces, and these do not separate the sculptured eye-piece and antenna. The body is stout, and when retracted the length is about three times the width. The genera of Agrotinae may be separated as follows:

a. Femora of the prothoracic legs visible.

b. Dorsal cephalic margin of the movable abdominal segments with a single even row of pits, numbering less than fifteen; epicranial suture present; cremaster often with a row of four setae near its proximal end .... *Agrotis* Ochsenheimer.

bb. Dorsal cephalic margin of the movable abdominal segments with an interrupted row of pits numbering more than fifteen; epicranial suture never present; cremaster never with a row of four setae near its proximal end ....*Hapalia* Hübner.
aa. Femora of the prothoracic legs never visible......*Noctua* Linnaeus.

The following species were examined:
Agrotis badinodis Grote, *bicarnea* Guenée
Hapalia incivis Guenée
Noctua clandestina Harris

Subfamily *Cucullianae*

As only two specimens of one genus, Graptolitha, were available for study, little can be said as to subfamily characters. These specimens differ from members of other subfamilies except the Catocalinae in having all the setae at the caudal end of the body hooked. There are two setae at the meson very much larger and more heavily chitinized than the remaining setae, which are usually four in number. In other respects, as the length of prothorax, size and shape of body, arrangement of appendages, presence of epicranial suture and labial palpi, exposed femora of the prothoracic legs, and traces of maxillary palpi, they resemble the Agrotinae and especially the Hadeninae as the movable abdominal segments are finely punctate along their cephalic margin.

The following species were studied:
Graptolitha laticinerea Grote, *antennata* Walker.

Subfamily *Hadeninae*

This subfamily includes pupae having stout straight setae or spines at the caudal end of the body. There are usually two, from 1–2 mm. in length, and they may be inserted in a short cremaster or directly in the caudal end of the body (Fig. 102). One genus, Cirphis, has additional slender hooked setae. The prothorax is very long, as in Agrotinae, at least two thirds the length of the mesothorax. The epicranial suture is present in the genera Polia, Hadena, Lycophotia, and Eriopus. The appendages, which in Agrotinae are of the same length and generally reach the caudal margin of the wings, are in this subfamily unequal in length. The maxillae usually reach the caudal margin of the wings, but the mesothoracic legs are shorter, and the antennae in some forms equal these or are very much shorter. Except for Cirphis and Monima the abdominal segments are punctate. These two genera have the movable abdominal segments pitted as in the

Agrotinae. The prothoracic leg extends cephalad to the eye-piece, but there is never a long point extending cephalad between the antennae and the sculptured eye-piece. The genera of Hadeninae may be separated by the following table:

a. Dorsum of movable abdominal segments with a row of deep pits along the cephalic margin.
  b. Caudal end of body with a very short cremaster ending in two straight sharp setae with four slender hooked setae at the proximal end, the hooked setae about half the length of the straight ones .... *Cirphis* Walker.
  bb. Cremaster very short, with a long straight seta inserted in each caudo-lateral angle; hooked setae never present. *Monima* Hübner.
aa. Dorsum of movable abdominal segments never with a row of deep pits along the cephalic margin.
  b. Mesothoracic leg never reaching cephalad to the eye-pieces; prothoracic femora always exposed.
    c. Caudal end of the abdomen with four closely approximated spines of the same size and shape.............. *Rhodophora* Guenée.
    cc. Caudal end of body with only two spines.
      d. Spiracles noticeably modified, usually with a prominent depression near their caudal margin; spiracular opening directed somewhat caudad; cephalic third of the movable abdominal segments usually slightly elevated and densely punctate.
        e. Cremaster slender, pointed, spines closely approximated; abdominal spiracles with a darker, elevated, crescent-shaped area almost surrounding the spiracle and with a deep cavity larger than the spiracle directly caudad of it; mesothoracic spiracles not modified........ *Meliana* Curtis.
        ee. Cremaster short, blunt; area around each abdominal spiracle slightly elevated and darker in color, a prominent cavity caudad of the spiracle with a chitinized ridge along the caudal margin of the spiracle; mesothoracic spiracles also modified, the opening extending half the distance between the antennae and the meson.
          f. Chitinized ridge along the caudal margin of the abdominal spiracles distinctly serrate; clypeal region not prominently elevated and without deeply impressed lines. *Laphygma* Guenée.
          ff. Chitinized ridge along the caudal margin of the abdominal spiracles not distinctly serrate; clypeal region prominently elevated and with deeply impressed lines. *Prodenia* Guenée.

dd. Spiracles normal, without any prominent elevations or depressions adjacent; cephalic third of the movable abdominal segments usually not elevated; segments punctate.

e. Epicranial suture present and distinct.

f. Cephalic third of movable abdominal segments with fine punctures, the remainder of the segments smooth; no cremaster present ....*Lycophotia* Hübner.

ff. Abdominal segments all finely punctate and with wavy impressed lines, more densely punctate along cephalic margin of the movable segments; a short, distinct rugose cremaster present ....*Hadena* Schrank.

ee. Epicranial suture wanting.

f. Abdominal segments 5–7 very finely punctate on the cephalic third ....*Chloridea* Westwood.

ff. Abdominal segments with very large, shallow punctures, at least on the cephalic third of segments 4–7.

g. Abdominal segments all punctate; segments 4–7 having the punctures very large on at least the cephalic two thirds of each segment and fine punctures on the remainder ....*Pyrrhia* Hübner.

gg. Abdominal segments 1–7 punctate; segments 4–7 with larger punctures on the cephalic half of each segment and usually with finer punctures on the remainder.
- *Polia* Ochsenheimer.

bb. Metathoracic leg reaching to the eye-piece; cephalic margin of tenth abdominal segment with a row of deep oblong pits; prothoracic femora never exposed...............*Eriopus* Treitschke.

The following species were examined:
Cirphis unipuncta Haworth, *phragmitidicola* Guenée
Rhodophora gaurae Smith and Abbot, *florida* Guenée
Meliana albilinea Hübner.
Laphygma frugiperda Smith and Abbot
Prodenia ornithogalli Guenée
Lycophotia margaritosa Haworth
Hadena vulgaris Grote
Chloridea obsoleta Fabricius, *virescens* Fabricius
Pyrrhia umbra Hüfnagel
Polia renigera Stephens, *picta* Harris, *meditata* Grote
Eriopus floridensis Guenée
Monima alia Guenée

Subfamily *Agaristinae*

The members of this subfamily show remarkable uniformity and it is rather difficult to separate the genera. They have been given family

rank by some authors, and while the species included here differ from the typical noctuid in many respects, still no structural characters could be found to warrant their separation from the Noctuidae. The entire body surface is very rough and spinose, while the cremaster is short, broad, and decidedly flattened, with its caudo-lateral angles produced into rounded lobes, and with the caudal margin often crenulate. There are sometimes short straight setae present along the caudal margin. The antennae, mesothoracic legs, and maxillae usually reach the caudal margin of the wings, or approach it very closely. Each prothoracic leg extends cephalad to the eye-pieces. The epicranial suture is always present. The labial palpi are always visible, but the femora of the prothoracic legs are concealed except in occasional specimens. The abdominal spiracles are somewhat elevated and are surrounded by a heavy, dark, chitinized border. The openings appear to be fringed with fine setae. The genera of this subfamily may be separated as follows:

a. Antennae always reaching the caudal margin of the wings; the row of spines along the caudal margin of the abdominal segments not larger than the spines of the segment; ninth abdominal segment never with scattered spines larger than those of the other segments.
  b. Dorsum of the abdominal segments rugose and densely spinose on the first nine segments ....*Euthisanotia* Hübner.
  bb. Dorsum of abdominal segments rugose and moderately spinose on the first seven segments; the eighth and ninth segments roughened, but with very few spines..........*Alypia* Hübner.
aa. Antennae never reaching the caudal margin of the wings; the row of spines along the caudal margin of the abdominal segments larger than those of the segment; ninth abdominal segment with scattered spines larger than those of the other segments.
Psychomorpha Harris.

The following species were examined:
Euthisanotia grata Fabricius, *unio* Hübner
Alypia octomaculata Fabricius
Psychomorpha epimenis Drury

Subfamily *Acronyctinae*

The subfamily Acronyctinae as typified by the genus Acronycta has little to distinguish it from other subfamilies except that the cremaster is short and usually mound-like and the setae are always of the same size and length. With this genus there are here included several others, which probably do not form a natural group, though all possess cremastral setae of the same size and length and in all the

members of the group only the prothoracic legs extend cephalad to the eye-pieces. All of these genera except Acronycta have prominent projections on the head and prothorax. The epicranial suture is present only in Eulonche. The labial palpi are well developed in all and the prothoracic femora are visible only in Eulonche, Acronycta, and Achatodes. The maxillae do not reach the caudal margin of the wings in any of the genera. The metathoracic legs are always visible, and in Eulonche the mesothoracic legs are adjacent on the meson. In Plusiodonta they extend to the caudal margin of the wings, but in none of the other genera. The antennae are usually equal in length to the mesothoracic legs and never reach the caudal margin of the wings. The genus Eulonche and a few species of Acronycta are very peculiar in that there are setae on the body arranged as in Arctiidae (Fig. 103). These are easily observed on the mesothorax and the parts of the abdomen where the sculpturing is not so dense. There are also a few short spines present on the tenth segment at the base of the cremaster. The genera of Acronyctinae may be separated as follows:

a. Cephalic end of body with two large, rounded, rugose projections on the head, one on each side of the meson.
  b. Dorsum of abdomen very rugose on segments 1–7 except for a smooth caudal margin; groups of long setae present on thorax and abdomen; epicranial suture present......*Eulonche* Grote.
  bb. Dorsum of abdomen never rugose, but with large lunate punctures on the cephalic third of segments 3–7; groups of long setae never present; epicranial suture absent. *Achatodes* Guenée.
aa. Cephalic end of body with a single median projection, or without projections.
  b. Cephalic end of body with a single median projection, either on the head or prothorax.
    c. A prominent projection on the body near the cephalic margin of the prothorax; abdominal segments 1–3 with a broad smooth transverse ridge near the caudal margin; movable abdominal segments with thin flanged plates; cremaster very short and broad, with a short, stout, slightly curved seta inserted in each caudo-lateral angle ....*Homopyralis* Grote.
    cc. Projection always present on the head; setae at the caudal end of the body always hooked.
      d. Distinct cremaster not present; a large sharp point at each caudo-lateral angle of the body, with some smaller points, and three short hooked setae inserted on each side: body distinctly punctate, with a smooth band at the caudal margin

of each segment; projection on the head blunt at the end and directed ventrad................*Plusiodonta* Guenée.

dd. Distinct cremaster present, its caudo-lateral angles produced and pointed, with two hooked setae inserted on the ventral side of each; body not punctate, slightly rugose; projection on the head narrowed to a rounded point. .*Anomis* Hübner.

bb. Cephalic end of body smooth, cremastral hooks slightly curved. *Acronycta* Treitschke.

The following species were examined:

Acronycta americana Harris, *populi* Riley, *clarescens* Guenée, *hamamelis* Guenée
Eulonche oblinita Smith and Abbot
Achatodes zeae Harris
Homopyralis discalis Grote
Plusiodonta compressipalpis Guenée
Anomis erosa Hübner

Subfamily *Phytometrinae*

The members of this subfamily differ markedly from those of the other subfamilies of Noctuidae. The labrum is never in its normal position but is located near the cephalic end of the body, while the wings and maxillae extend beyond the caudal margin of the fourth abdominal segment. The wings are produced into a sharp point near the meson of the ventral surface. The labial palpi are always visible and a large portion of the prothoracic femur is exposed. The dorsal cephalic margin of the movable abdominal segments has a number of prominent furrows with slightly serrate ridges between. The prothorax is not as long as in the previously mentioned subfamilies, being only two fifths the length of the mesothorax, and the caudo-lateral angles are somewhat produced. The dorsal surface of the body shows prominent grooves along the caudal margin of the metathorax and the first four abdominal segments. The edges of these grooves are somewhat serrate. The cremaster is somewhat cylindrical and rugose, with two long hooked setae and four shorter ones. The two genera studied are very closely related and may be separated as follows:

a. Antenna reaching the caudo-lateral angle of the mesothoracic leg; cremaster with length and breadth approximately equal and longer than its longest setae.......................*Phytometra* Haworth.

aa. Antenna much shorter than the mesothoracic leg and never reaching its caudo-lateral angle; cremaster always longer than broad and about equal in length to its longest setae. *Syngrapha* Hübner.

The following species were examined:
Phytometra brassicae Riley
Syngrapha falcigera Kirby

Subfamily *Mominae*

The only genus studied in this group was Charadra. This resembles the Arctiidae very much more than it does most Noctuidae in the shape of the body, in the presence of setae arranged around the scars of larval verrucae, and in the absence of epicranial suture and visible labial palpi and femora of the prothoracic legs. The antennae are broader at the proximal end than is typical in Noctuidae. The appendages are arranged more as they are in Noctuidae and there is a cremaster present, as long as the ninth and tenth abdominal segments, which bears hooked setae. The only known Arctiidae which have long cremasters are provided with flanged plates on the movable abdominal segments and the cremastral setae are never hooked. The prothoracic leg extends cephalad between the sculptured eye-piece and the antenna, but the mesothoracic leg never reaches the eye-pieces. The body is slightly punctate along the cephalic margin of the movable abdominal segments. The pupae are found in thin silken cocoons, which differ from those of the species of Arctiidae in that none of the larval hairs are used in their construction.

The following species was the only one examined:
Charadra deridens Guenée.

Subfamily *Hypeninae*

The only genus available for study of this group as given in Dyar's list was Plathypena, but as Balsa possesses the pupal characters which distinguish this from other subfamilies, it is included in the Hypeninae for the present. These characters are the presence of two long and six short hooked setae at the caudal end of the body and the fact that the prothoracic legs and the long point of the mesothoracic legs extend cephalad to the eye-piece, or, as in Balsa, to the maxillary palpus, which is always present in this genus. Plathypena shows the epicranial suture, but it is not found in Balsa. Both genera have the spiracles slightly produced, and in Plathypena they are on small elevations. The labial palpi are present in both, but the femora of the prothoracic legs are visible only in Balsa. The genera may be separated as follows:

a. Dorsum of prothorax, metathorax, and first three abdominal segments with a distinct median ridge; antennae and mesothoracic legs reaching the caudal margin of the wings and longer than the maxillae; caudal margin of mesothorax never with a row of shallow depressions .... *Plathypena* Grote.

aa. Dorsum of body never with a median ridge; antennae and mesothoracic legs not reaching the caudal margin of the wings and not longer than the maxillae; caudal margin of mesothorax with a row of shallow depressions .... *Balsa* Walker.

The following species were examined:
Plathypena scabra Fabricius
Balsa malana Fitch

Subfamily *Catocalinae*

This group is distinguished from all other noctuids by the presence of a whitish "bloom" on the surface of the pupa, which is retained even in alcoholic specimens. Both prothoracic and mesothoracic legs extend cephalad to the eye-pieces. The labial palpi are always present, but the femora of the prothoracic legs are seldom visible. The epicranial suture is found throughout the genera Catocala and Eunetis but is lacking in the remainder of the subfamily. The antennae, mesothoracic legs, and maxillae either reach the caudal margin of the wings or very closely approach it. The cremaster is usually very short or absent, and the setae at the caudal end of the body are usually of two sizes and inserted at different levels except in the genus Eunetis. This generic name is applied to certain species of the genus Catocala of Dyar's list which have a short cremaster, slightly broader at the caudal end, bearing about eight slightly curved setae which are usually directed towards the meson. The following table will serve to separate the genera of Catocalinae:

a. Epicranial suture present; body tapering rapidly from the fifth abdominal segment so that it is more slender in appearance than the typical noctuid, the lateral margins of abdominal segments 8–10 as seen in dorsal view convergent and not strongly convex.

  b. Cremaster, if present, very short and narrowed at the caudal end, and with eight long hooked setae of two sizes, some larger and more heavily chitinized than the others....... *Catocala* Schrank.

  bb. Cremaster broadened at the caudal end, usually with eight short, stout setae which are slightly curved and usually directed towards the meson .... *Eunetis* Hübner.

aa. Epicranial suture not present; body of typical noctuid shape, with the lateral margins of abdominal segments 8–10 distinctly convex as seen in dorsal view.

b. Head with a distinct tubercle near the base of each antenna.
Euparthenos Grote.

bb. Head without a distinct tubercle at the base of each antenna.

c. Thorax and appendages with deep indeterminate transverse striations; median caudal spines of cremaster somewhat enlarged near the tip; metathoracic legs never present.
Pheocyma Hübner.

cc. Thorax and appendages approximately smooth; median caudal spines of cremaster never enlarged near the tip; metathoracic legs always apparent caudad of the maxillae.

d. Cremaster with spines practically all of the same size, no two being larger and longer than the others. .*Caenurgia* Walker.

dd. Cremaster with two spines larger and longer than the others.
Zale Hübner.

The following species were examined:

Euparthenos nubilis Hübner
Pheocyma lunifera Hübner
Caenurgia erechtea Cramer, *crassiuscula* Haworth
Zale calycanthata Smith and Abbot, *lunata* Drury
Catocala illecta Walker, *unijuga* Walker, *briseis* Edwards, *verecunda* Hulst, *aholibah* Strecker, *ilia* Cramer, *innubens* Guenée, *neogama,* Smith and Abbot, *pacta* Linnaeus, *sponsa* Linnaeus
Eunetis blandula Hulst, *ultronia* Hübner, *grynea* Cramer

Subfamily *Sarrothripinae*

This group is readily distinguished because it has neither cremaster nor setae at the caudal end of the body, which is probably due to the fact that its members are found in thick cocoons. The dorsal surface of the body is very irregularly rugose with spinous elevations, and there is a distinct row of spines along the caudal margin of the fifth abdominal segment extending from the rugose area on the dorsum around nearly to the meson of the ventral surface. A few spines are present in a similar position on the fourth abdominal segment. The epicranial suture is always present, the labial palpi are visible for their entire length, and only a small portion of the prothoracic femur is exposed, or it may be entirely concealed. The maxillae never reach the caudal margin of the wings, being about seven eighths of their length, with the mesothoracic legs meeting just caudad of them. The antennae always reach to the caudal margin of the wings, while the mesothoracic legs do not, but the latter are slightly longer than the maxillae. Both prothoracic and mesothoracic legs extend cephalad to the eye-piece, the mesothoracic legs extending between the sculptured eye-piece and the antenna.

The members of this subfamily have been treated as the family Nycteolidae by some authors, but there is no evidence in the pupae to separate them from the family Noctuidae.

The following species were examined:

Sarrothripus revayana Scopoli, *protcella* Dyar.

Family Arctiidae

The members of this family all possess distinct setae arranged around the scars of the larval verrucae. These setae are seldom conspicuous enough to be seen with the naked eye as in Liparidae, but are easily visible with the aid of the microscope. The labial palpi are never visible, unless as small triangular areas caudad of the labrum, except in Halisidota, where they are exposed for their entire length. The femora of the prothoracic legs are never visible. The shape of the body is characteristic, being slightly concave on the dorsum in the region of the metathorax (Fig. 104). Certain genera of Noctuidae, Acronycta, Eulonche, and Charadra, also show setae arranged around the scars of the larval verrucae. In the two genera first named, both labial palpi and prothoracic femora are exposed, while Charadra possesses a long cremaster bearing hooked setae. Those genera of Arctiidae with a cremaster never have hooked setae, but all cremastral setae are flattened at the distal end. The epicranial suture is never present in any member of this family. The prothorax is usually long, often half the length of the mesothorax as in most Noctuidae. The genus Ctenucha, included with the Syntomidae in Dyar's list, shows no characters to distinguish it from the Arctiidae and it is probable that other genera of this family should be included here. The genera of Arctiidae may be separated as follows:

a. Abdominal segments 5–7 never with a flanged plate along the cephalic margin, or with deep furrows between these segments when the body is retracted; maxillae nearly as long as the wings; mesothoracic wings never meeting on the meson caudad of the appendages.

b. Dorsal surface of abdomen flattened; body broadly rounded at caudal end and bearing a row of short setae which are slightly curved at tip; body brown, concolorous.

c. Labial palpi showing for about one sixth of the length of the maxillae; body 18–20 mm. in length; dorsal surface of abdomen never with depressed areas .... *Halisidota* Hübner.

cc. Labial palpi never showing except as a small triangular piece about a millimeter in length; body 12–15 mm. in length; dorsal surface of abdomen with depressed areas on meson of each segment at cephalic margin and one on each side adjacent to the spiracles .... *Euchaetias* Lyman.

bb. Dorsal surface of abdomen not flattened; body tapering at caudal end; color yellowish or chestnut-brown, strikingly marked with black.

c. Distinct cremaster present.................. *Haploa* Hübner.

cc. Distinct cremaster never present.

d. Antennae about seven eighths the length of the wings; maxillae never reaching the caudal margin of the wings.
Utetheisa Hübner.

dd. Antennae as long as the wings; maxillae always reaching the caudal margin of the wings............. *Ctenucha* Kirby.

aa. Abdominal segments 5–7 with a flanged plate along the cephalic margin, and with deep furrows between the movable segments when the body is retracted; maxillae never as long as the wings, usually about two thirds the length; mesothoracic wings always meeting on the meson caudad of the appendages.

b. Abdominal segments 4–6 with a similar flanged plate adjacent to the caudal margin of the segment.

c. Appendages, and usually the thorax, roughened with indeterminate transverse striations; abdominal segments densely, coarsely punctate.

d. Head with a small tubercle at the proximal end of each antenna; antennae always much shorter than the prothoracic legs .... *Estigmene* Hübner.

dd. Head without a tubercle at the proximal end of each antenna; antennae as long as, or longer than, the prothoracic legs.

e. Body usually 18–20 mm. in length, stout; setae of the cremaster of various sizes and lengths, the shortest ones only about half the length of the longest, and irregularly arranged, always fifteen or more in number.
Diacrisia Hübner.

ee. Body seldom over 12 mm. in length, varying from 10–15 mm., rather slender; setae of the cremaster of practically the same size and length, arranged in two transverse rows, with four in the dorsal and eight in the ventral row, never as many as fifteen in number .... *Hyphantria* Harris.

cc. Thorax and appendages smooth and polished; body sparsely, finely punctate .... *Ecpantheria* Hübner.

bb. Abdominal segments 4–6 never with a flanged plate adjacent to the caudal margin.

c. Distinct cremaster always present and long, bearing setae at the caudal end; antennae about equaling the maxillae in length, usually three fourths the length of the wings.
Apantesis Walker.

cc. Distinct cremaster never present; a row of setae at the caudal end of the body; antennae very much shorter than the maxillae, being about half the length of the wings. . . . *Isia* Walker.

The following species were examined:
Halisidota tessellaris Smith and Abbot, *caryae* Harris
Euchaetias egle Drury
Haploa clymene Brown
Utetheisa bella Linnaeus
Ctenucha virginica Charpentier
Estigmene acraea Drury
Diacrisia virginica Fabricius
Hyphantria cunea Drury
Ecpantheria deflorata Fabricius
Apantesis virgo Linnaeus, *michabo* Grote, *arge* Drury, *phyllira* Drury, *nais* Drury
Isia isabella Smith and Abbot

Family Liparidae

This family, like the Arctiidae, is characterized by the presence of setae arranged around the scars of the larval verrucae. In the Liparidae the setae are long and coarse, and easily visible to the unaided eye. With the exception of Porthetria all the genera examined show a characteristic arrangement of appendages (Fig. 105). In Porthetria the labial palpi were usually concealed by the maxillae, although a large number of pupae show them present, as in Figure 105. The epicranial suture is never present. The maxillae are always short, never more than two fifths the length of the wings. The legs are usually shorter than in most pupae, the mesothoracic legs never reaching the caudal margin of the wings. The antennae are pectinate and are longer and broader in the male than in the female. The cremaster is always present, smooth, longer than broad, and bears short hooked setae at the distal end.

Most of the species examined show a remarkable uniformity of characters, and considerable difficulty was encountered in separating the genera. The difficulty lies in the fact that there is considerable difference between the sexes, not only in the length and breadth of the antennae, but in the size and arrangement of other appendages. In Hemerocampa the adult females are apterous, and the wings in the pupa are not as long as in the males. The wings of the females reach slightly over the cephalic margin of the fourth abdominal segment, while in the male they reach to the caudal margin of that segment. In Hemerocampa the dorsum of the first three abdominal segments is covered on each side of the meson with small vesicles. The following table will serve to separate the genera of Liparidae:

a. Spiracular furrows never present on the cephalic margin of the movable abdominal segments; labial palpi present and well developed; long setae not present on the face-parts near the caudal margin of the head, on the clypeus, or on the sculptured eye-pieces.

b. Labial palpi about equal in width to each maxilla; cremastral setae about one third the length of the cremaster.

c. Dorsal surface of abdomen densely covered with long setae; body brown, concolorous except sometimes for the lighter transverse conjunctiva; antennae with the stem of the flagellum very broad and distinctly elevated.

d. Abdominal segments 8–10, in dorsal view, distinctly narrowed and tapering; clypeus and labrum on a level with the other face-parts; cremaster directed caudad; antennae of male reaching about half the distance along the mesothoracic legs, and distinctly pointed ....*Dasychira* Stephens.

dd. Abdominal segments 8–10, in dorsal view, not narrowed and distinctly tapering; clypeus and labrum both elevated above the level of the other face-parts; cremaster directed dorsad; distal half of the antennae of the female distinctly narrowed and pointed, reaching about half the distance along the mesothoracic legs ....*Olene* Hübner.

cc. Dorsal surface of abdomen not very densely covered with setae; body white variously marked with brown, or vice versa; antennae in both sexes with the stem of the flagellum scarcely indicated and the distal end always rounded, in the male extending about half the length of the wings and curved mesad so that they often meet, in the female never reaching half the distance along the mesothoracic legs and never meeting on the meson.
Hemerocampa Dyar.

bb. Labial palpi only half the width of each maxilla; cremastral setae about half the length of the cremaster; antennae in the male broad for almost their entire length and extending about three fourths the length of the wings, adjacent or meeting on the meson, in the female pointed at the distal end and reaching about half the distance along the mesothoracic legs.
Euproctis Hübner.

aa. Spiracular furrows always present on the cephalic margin of the movable abdominal segments and extending almost to the meson, five or six in number and separated by sharply carinate ridges; caudal portion of face-parts, clypeus, and sculptured eye-pieces with coarse setae similar to those on the body, labial palpi often concealed, but sometimes visible as in the remainder of the family.
Porthetria Hübner.

The following species were examined:

Dasychira pudibunda Linnaeus
Olene manto Strecker

Hemerocampa leucostigma Smith and Abbot
Porthetria dispar Linnaeus
Euproctis chrysorrhoea Linnaeus

Superfamily BOMBYCOIDEA

This superfamily includes those families in which the body is more or less densely covered with setae and which usually retain the labial palpi. They seem to be more nearly related to the Saturnioidea than to any other superfamily, although the Lasiocampidae show certain points of relationship with the Liparidae. All the members of the superfamily, so far as known, are found in thick silken cocoons, much like those of the Saturniidae. The families of Bombycoidea may be separated as follows:

a. Epicranial suture present; labial palpi visible.......Lasiocampidae.
aa. Epicranial suture never present; labial palpi concealed by the maxillae except for a small triangular area at the proximal end. Bombycidae.

Family Lasiocampidae

The members of this family usually have mouth parts and appendages arranged as in the Liparidae (Fig. 106). The epicranial suture is always present and the vertex is longer than that found in any but the more generalized forms. The maxillae are short, never more than one third the length of the wings, and extend very slightly beyond the distal ends of the labial palpi, or may be shorter than the palpi.

The antennae are broad and pectinate, and never extend as far caudad as the prothoracic legs. The coxae of the prothoracic legs and sometimes of the mesothoracic pair are often visible caudad of the maxillae and labial palpi. The prothoracic legs are slightly more than half the length of the wings and the mesothoracic legs never reach the caudal margin of the wings. The setae of the body are very conspicuous except in Tolype, but are not arranged around the scars of the larval verrucae. The movable segments are capable of being retracted till only their caudal margins are visible. There is never a cremaster present, and there are no hooked setae at the caudal end of the body. The body is broadly rounded at the caudal end and the body setae are usually a little longer and coarser in this region. This family is considered by many authors to be more specialized than any of the Saturnioidea, but the presence of the epicranial suture and exposed labial palpi shows that they are much more generalized. The genera of Lasiocampidae may be separated as follows:

a. Entire surface of body except the appendages with a dense covering of fine short setae, giving it a furred appearance; abdominal segments 8–10 considerably narrower than the remainder of the abdomen .... *Malacosoma* Hübner.

aa. Entire surface of body except appendages never with a dense covering of setae giving it a furred appearance, either with a very sparse covering, or without visible setae; abdominal segments 8–10 not noticeably narrower than the remainder of the abdomen.

b. Body sparsely covered with very fine short setae except at the caudal end, where they are longer and coarser; tenth segment broadly rounded at the caudal end.

c. Lateral surface of abdomen on either side of the spiracles with setae much thicker than on the dorsum; dorsal surface of abdomen very coarsely punctate .... *Lasiocampa* Schrank.

cc. Lateral surface of abdomen on either side of the spiracles never with the setae more numerous than on the dorsum; dorsal surface of abdomen very finely punctate.... *Cosmotriche* Hübner.

bb. Body without any visible covering of setae; tenth segment abruptly narrowed at the caudal end, suggesting a cremaster.
Tolype Hübner.

The following species were examined:
Malacosoma americana Fabricius, *disstria* Hübner
Lasiocampa quercus Linnaeus (Europe)
Cosmotriche potatoria Linnaeus (Europe)
Tolype velleda Stoll

Family Bombycidae

This family includes the genus Bombyx, which is domesticated in various parts of the world (Fig. 107). The body is covered with rather coarse short setae which are somewhat longer at the caudal end of the body. The epicranial suture is never present. The appendages are arranged much as in Lasiocampidae. The labial palpi are almost concealed, being overlaid by large ovate appendages, appearing to be heavily veined, which are presumably the maxillae (no dissections were made of this species). The mandibles are represented by strongly elevated tubercles. The coxae of one pair of legs, probably the mesothoracic, are adjacent on the meson caudad of the maxillae. The legs are short, and both prothoracic and mesothoracic pairs lie adjacent on the meson. The antennae are pectinate, broad at the proximal end and rapidly narrowed, ending in a point opposite the distal ends of the prothoracic legs. The mesothoracic wings lie adjacent on the meson caudad of the mesothoracic legs. The movable segments may be retracted so that only their caudal margins are visible. There is no cremaster present. The pupa strongly re-

sembles those of certain species of Saturniidae and it is quite probable that they had a common ancestor, although the Bombycidae are undoubtedly more generalized. The only species in America is *Bombyx mori* Linnaeus.

Superfamily NOTODONTOIDEA

The families included here never have the entire labial palpi exposed, but a very small triangular or polygonal area is sometimes visible just caudad of the labrum. Some genera of Geometridae have the prothoracic femora exposed, while the epicranial suture is present in some of the members of each family. Although the larvae of Geometridae are easily recognized and are very readily distinguished from those of the Notodontidae, the pupae show much closer relationships, and it is difficult to draw a hard and fast line between the two families. The three families included here have probably had a common ancestor, and although the Dioptidae retain the epicranial suture they must be considered the most specialized, as both Geometridae and Notodontidae show more generalized characters in some of their genera. The following table may be used to separate the families of Notodontoidea:

a. Antennae never extending beyond the caudal margin of the wings; dorsum of abdomen never with a prominent hooked seta on each side of the meson of segments 7–10.

- b. Maxillae usually more than three fifths the length of the wings, if not, then the caudal end of the body with hooked setae, or the spiracles of the third abdominal segment concealed by the wings and those of the sixth segment farther ventrad than those of the other segments; prothoracic femora often exposed; a deep furrow usually present on the dorsum of the abdomen between the ninth and tenth segments; caudal margin of mesothorax never with a row of deep pits with smooth tubercle-like areas between. Geometridae.
- bb. Maxillae seldom exceeding three fifths the length of the wings, if so, then the caudal margin of the mesothorax with a row of deep pits with smooth, elevated, quadrangular tubercle-like areas between them; or with the entire body surface coarsely punctate; abdominal spiracles of the third segment never concealed by the wings, and those of the sixth never farther ventrad than the remainder; prothoracic femora never exposed; a furrow never present on the dorsum of the abdomen between segments 8 and 9 except in Datana, where the cremaster is of the type shown in Figure 112 ....Notodontidae.

aa. Antennae extending beyond the caudal margin of the wings; dorsum of abdomen with a prominent hooked seta on each side of the meson of segments 7–10 ....DIOPTIDAE.

Family GEOMETRIDAE

The pupae in this family (Figs. 108 and 109) never have the labial palpi exposed except as small triangular or polygonal areas caudad of the labrum. The maxillary palpi are never present. The epicranial suture is present in some of the genera in Groups A and C. Some of the genera have the femora of the prothoracic legs exposed. In all the genera examined, either the prothoracic or mesothoracic leg, or sometimes both, extended cephalad between the sculptured eye-piece and the antenna. The prothoracic and mesothoracic legs are longer than is usual in most families, the former being usually three fourths the length of the wings, while the latter always extend to the caudal margin of the wings. Many of the genera show the fronto-clypeal suture extending from the proximal ends of the antennae and directed caudad towards the invaginations for the anterior arms of the tentorium. The suture is very distinct for the cephalic part and is often indicated by a slight furrow for the remainder of the distance. In the genus Haematopsis there is a prominent cephalic projection bearing hooks which hold the suspensory threads, as this pupa is not found in a cocoon. The antennae vary little throughout the family, and are generally equal in width to, or wider than, the prothoracic legs, usually extending to the caudal margin of the wings. The mesothoracic wings usually extend farther caudad than in the nearly related families, reaching almost to the caudal margin of the fourth abdominal segment, although not visible in ventral view. The mesothorax is very short in some genera, particularly in those of Group D, where it is never twice the length of the prothorax. The mesothoracic spiracles very often have a decided projection adjacent to their caudal margin, which is usually flattened or tuberculate in form and often covered with very fine short setae. The abdominal spiracles are sometimes produced, and in nearly all genera the sixth spiracle, and sometimes the seventh also, is considerably farther ventrad than the remainder. The abdomen is usually coarsely punctate, sometimes roughened with deep transverse striations. A cremaster of some kind is always present. One of the most interesting structures of the abdomen is the dorsal furrow between the ninth and tenth segments. This is usually deep and fringed with very fine setae. This furrow frequently projects caudad on the lateral surface of the body and this portion is often separated from the dorsal furrow. This dorsal fur-

row is present in all members of Group A except Ennomos and in a few members of Group D. These dorsal furrows are found in other families, notably in the Gelechiidae and some Pyralididae.

The attempt to classify the pupae of Geometridae was seriously hampered by lack of material. Reared material was very hard to obtain, as the larvae develop slowly and seem to be very susceptible to disease. The available material, moreover, did not seem to fall in with any of the existing schemes of classification, so that the only practical solution of the difficulty was to divide them into groups according to the pupal characters. These may or may not be natural groups, but they will serve to indicate relationships in some degree. According to the pupal characters there seem to be two large divisions, one with hooked setae on the cremaster, the other without them. As the presence of hooked setae is a more generalized character, the groups in which they are present should be the more generalized, and the presence of the epicranial suture strengthens this view. Group A includes representatives of the subfamilies Sterrhinae, Ennominae, and Hydriomeninae as listed by Dyar. Group B includes for the present only the genus Haematopsis. Group C includes the genera Alsophila and Brephos, which are similar in many respects and possess the same type of cremaster. This must also be considered as a generalized group since the epicranial suture is present in Alsophila. Brephos has usually been considered as the most generalized geometrid, but no epicranial suture has been located. The maxillae are also much shorter in Alsophila. In Group D the epicranial suture is never present. Spiracular furrows are frequently found in Groups A and D. The adult females of some of the geometrid species are apterous. Although abundant material of one such species, *Paleacrita vernata,* was examined, the pupal wings were found as well developed in the female as in the male. These groups of Geometridae may be separated as follows:

a. Cremaster with hooked setae.

b. Setae of the cremaster always of two sizes, usually either the two or four farthest caudad much larger than the others; dorsum of abdomen usually with a deep furrow between abdominal segments 9 and 10; body never with a bifurcate projection at the cephalic end .... Group A.

bb. Setae of the cremaster always of the same size; dorsum of abdomen never with a furrow between segments 9 and 10; body with a long bifurcate projection at the cephalic end, densely covered with hooked setae .... Group B.

aa. Cremaster never with hooked setae.
  b. Cremaster a stout T-shaped spine.................... GROUP C.
  bb. Cremaster always bifurcate .... GROUP D.

Group A

This group includes species in which the cremastral setae are of two sizes, and which generally show the epicranial suture, and a dorsal furrow between the ninth and tenth abdominal segments (Fig. 109). Spiracular furrows are also frequently present. The genera included in this group may be separated as follows:

a. Epicranial suture always present; prothoracic femora always exposed, usually a large portion; spiracular furrows never present; dorsum of abdomen with a distinct furrow between segments 9 and 10, and also on the lateral surface of segment 10.
  b. Dorsum of fifth abdominal segment with a distinct furrow on the cephalic margin; caudal margin of the furrow between the ninth and tenth abdominal segments with finely serrate edges and without setae .... *Hydria* Hübner.
  bb. Dorsum of fifth abdominal segment never with a distinct furrow on the cephalic margin; caudal margin of the furrow between the ninth and tenth abdominal segments coarsely serrate.
    c. Prothoracic and mesothoracic legs extending cephalad between the sculptured eye-piece and the antenna, the mesothoracic leg extending almost as far cephalad as the prothoracic; caudal margin of the furrow between the ninth and tenth abdominal segments without setae; cremaster distinctly constricted at the proximal end and circular in outline........... *Eois* Hübner.
    cc. Prothoracic leg extending cephalad between the sculptured eye-pieces and the antenna, the mesothoracic leg never reaching farther cephalad than the caudal margin of the eye-piece; caudal margin of the furrow between the ninth and tenth abdominal segments usually fringed with fine setae; cremaster not constricted at the proximal end, triangular in outline.
      d. Cremaster with hooked setae of nearly the same size, the median caudal setae being only slightly larger than the others; three setae inserted along each side of the cremaster, the other two cephalad of these and slightly mesad. *Tephroclystis* Hübner.
      dd. Cremaster with the hooked setae of widely differing sizes, the two median caudal setae being much larger and longer than the others, a smaller seta adjacent on each side, while the other setae are arranged in a tranverse row just cephalad of the caudal setae........................ *Cinglis* Guenée.

aa. Epicranial suture never present.

b. Prothoracic femora exposed, but only a very narrow portion.

c. Spiracular furrows present on the fifth abdominal segment; ventral surface of head with a prominent transverse ridge extending from about the middle of the glazed eye-piece; body setae arising from small dark brown or black papillae. . *Philobia* Duponchel.

cc. Spiracular furrows never present on the fifth abdominal segment; ventral surface of head never with a transverse ridge; body setae arising from small pits. . . . . *Sabulodes* Guenée.

bb. Prothoracic femora never exposed.

c. Antennae distinctly elevated and covered with five or six rows of small round tubercles; distinct ridges or flanged plates present along both margins of the movable segments.

d. Cremaster with the two median caudal spines very much larger than the others; distinct furrow always present between the ninth and tenth abdominal segments; color dark brown.
Nacophora Hulst.

dd. Cremaster with the four caudal spines about the same size and much larger than the others; distinct furrow never present between the ninth and tenth abdominal segments; color usually white, sometimes partly brown.
Ennomos Treitschke.

cc. Antennae elevated but never with distinct rows of tubercles; ridges or flanged plates never present on the movable segments.

d. Maxillae about two thirds the length of the wings; prothoracic mesothoracic, and metathoracic legs all meeting on the meson caudad of the maxillae. . . . . *Xanthotype* Warren.

dd. Maxillae always more than two thirds the length of the wings; prothoracic and mesothoracic legs never meeting on the meson caudad of the maxillae.

e. Spiracular furrows present on the cephalic margin of the fifth abdominal segment, with more or less interrupted ridges between; cremaster with the four caudal setae always larger than the others. *Ania* Stephens.

ee. Spiracular furrows never present on the cephalic margin of the fifth abdominal segment, cremaster with two caudal setae larger than the others. . . . . *Cingilia* Walker.

Group B

The pupae of this group are easily distinguished by the long bifurcate projection at the cephalic end of the body, which is covered with hooked setae. There are never spiracular furrows present on the cephalic margin of the movable segments. The mesothoracic legs meet on the meson caudad of the maxillae. The body is very slender and never punctate. This group includes the genus Haematopsis.

Group C

The species of this group are distinguished by the peculiar T-shaped cremaster. The genera may be separated as follows:

a. Epicranial suture present; prothoracic and mesothoracic legs meeting on the meson caudad of the maxillae............*Alsophila* Hübner.
aa. Epicranial suture never present; prothoracic and mesothoracic legs never meeting on the meson caudad of the maxillae. *Brephos* Ochsenheimer.

Group D

This group is characterized by the presence of a bifurcate cremaster. The epicranial suture is never present, but a portion of the prothoracic femora is exposed in many genera. The following table will serve to separate the genera of this group:

a. Prothoracic femora visible.
  b. Cephalic margin of the fifth abdominal segment with one deep spiracular furrow with strongly chitinized edges, just cephalad of each spiracle.
    c. Mesothoracic spiracle with a broad, very strongly elevated ridge or oval tubercle adjacent to its caudal margin which is covered with fine short setae; surface of spiracular furrow with distinct punctures ....*Physostegania* Warren.
    cc. Mesothoracic spiracle with only a very narrow, slightly elevated ridge adjacent to its caudal margin, usually covered with setae; surface of spiracular furrow without distinct punctures.
      d. Dorsal surface of abdomen never with a distinct furrow between the ninth and tenth segments, its caudal margin finely serrate; surface of the spiracular furrow almost smooth. *Ectropis* Hübner.
      d. Dorsal surface of abdomen never with a distinct furrow between the ninth and tenth segments; surface of the spiracular furrows strongly rugose.....................*Cleora* Curtis.
  bb. Fifth abdominal segment without any deep spiracular furrow; cephalic margin of the segment deeply punctate, the punctures sometimes confluent; mesothoracic spiracle with a broad strongly elevated ridge or tubercle adjacent to its caudal margin; dorsal surface of abdomen without a distinct furrow between the ninth and tenth segments....*Cymatophora* Hübner.
aa. Prothoracic femora never visible; deep spiracular furrows always present on the cephalic margin of the fifth abdominal segment; mesothoracic spiracle always with a prominent elevation adjacent to its caudal margin.
  b. Dorsal surface of abdomen never with a furrow between the ninth and tenth segments; abdominal spiracles very strongly produced;

cremaster often showing two lateral setae on each side near the proximal end.

bb. Dorsal surface of abdomen with a distinct furrow between the ninth and tenth segments, its caudal margin coarsely serrate; a prominent lateral depression or furrow present on the lateral surface of the tenth abdominal segment.

c. Maxillae four fifths the length of the wings or less; mesothoracic legs meeting on the meson just caudad of the maxillae; antennae more than twice as wide at the proximal as at the distal end .... *Lycia* Hübner.

cc. Maxillae always more than four fifths the length of the wings; mesothoracic legs never meeting on the meson caudad of the maxillae; antennae of almost the same width throughout, never twice as wide at the proximal as at the distal end. *Erannis* Hübner.

The following species were examined:

Group A

Hydria undulata Linnaeus
Eois inductata Guenée
Tephroclystis interruptofasciata Packard, *absinthiata* Clerck
Cinglis similaria Walker
Philobia enotata Guenée
Sabulodes lorata Grote, *transversata* Drury
Nacophora queruaria Smith and Abbot
Ennomos subsignarius Hübner, *magnarius* Guenée
Xanthotype crocataria Fabricius
Ania limbata Haworth
Cingilia catenaria Drury
Cosymbia serrulata Packard

Group B

Haematopsis grataria Fabricius

Group C

Alsophila pometaria Harris
Brephos infans Möschler

Group D

Physostegania pustularia Guenée
Ectropis crepuscularia Denis and Schiffermueller
Cleora pampinaria Guenée
Cymatophora ribearia Fitch
Paleacrita vernata Peck
Lycia cognataria Guenée
Erannis tiliaria Harris

Family Notodontidae

The pupae of this family never show more than a small triangular or polygonal proximal portion of the labial palpi, and maxillary palpi are never present. The femora of the prothoracic legs are never exposed. The epicranial suture is present in the genera Apatelodes and Melalopha. The maxillae never reach the caudal margin of the wings. The antennae are always widest at their proximal ends, and there the width exceeds the greatest width of the prothoracic legs. Each antenna tapers gradually to a pointed tip and the tips often lie adjacent on the meson caudad of the other appendages. The metathoracic legs are seldom visible. The mesothoracic leg never reaches cephalad to the eye-pieces. The abdomen is always punctate and in most species the punctures are large. A cremaster is usually present and there are various types, as in Figures 111, 112, 113. Packard divided the Notodontidae into six subfamilies. The pupae examined show that these subfamilies are well founded, but only tables to genera are given here as so few species of Notodontidae were examined. The genera Schizura and Heterocampa are not well defined and the species are separated with difficulty. The species are listed, however, under the subfamily name.

Some authors believe that the genus Apatelodes belongs to the European family Eupterotidae, and is incorrectly listed with the Notodontidae. As no pupae of Eupterotidae have been examined, it is impossible to say whether pupal characters would justify this change. There are, however, no pupal characters as far as observed, which would prevent its being included with the Notodontidae. The two species differ widely and are possibly not congeneric. The following tables will serve to separate the genera of Notodontidae:

a. Maxillae one third, or less, the length of the wings; both prothoracic and mesothoracic legs meeting on the meson caudad of the maxillae; abdomen very finely punctate.
  b. Thorax and abdomen thickly covered with very fine, short setae; cremaster a stout spine about one millimeter in length with two short recurving hooks at the tip, each of which bears two or more very fine setae............................*Melalopha* Hübner.
  bb. Thorax and abdomen never thickly covered with fine, short setae; cephalic margin of first abdominal segment without tubercles; cremaster never as described above, sometimes absent.
    c. Abdominal segments 2–7 with distinct flanged plates at both cephalic and caudal margins, the cephalic plate interrupted by deep pits, giving it the appearance of a row of square tubercles; appendages not at all elevated, making a smooth even

surface; cephalic end of body not elevated between the antennae; short cremaster sometimes present.

Apatelodes Packard.

cc. Abdominal segments 2–7 never with flanged plates; appendages distinctly elevated; cephalic end of body elevated between the antennae; cremaster never present.

Harpyia Ochsenheimer.

aa. Maxillae always more than one third the length of the wings; never with both prothoracic and mesothoracic legs meeting on the meson; abdomen usually rather coarsely punctate.

b. Maxillae from one half to three fifths the length of the wings; mesothoracic legs meeting on the meson caudad of the maxillae; appendages roughened with deep indeterminate striations; abdominal segments coarsely punctate; a distinct, deep furrow on the dorsum between the ninth and tenth abdominal segments; cremaster short, bifurcate, each half with several short spiny processes, usually directed laterad............*Datana* Walker.

bb. Maxillae more than three fifths the length of the wings; neither prothoracic nor mesothoracic legs meeting on the meson caudad of the maxillae; appendages usually with shallow indeterminate striations; a distinct furrow never present on the dorsum between the ninth and tenth abdominal segments; cremaster not as described above.

c. Entire body surface with coarse, deep punctures; cephalic margin of the movable abdominal segments with large lunate punctures and a distinct ridge with a row of large, very distinct punctures just caudad of the ridge; cremaster short, rugose, slightly bifurcate, bearing six long hooked setae; mesothorax never with a deeply pitted caudal margin.

Symmerista Hübner.

cc. Body usually punctate on the abdomen, but not on the appendages; movable abdominal segments sometimes with a slight ridge along the cephalic margin, but never with a distinct row of large punctures caudad of the ridge; cremaster bifurcate, but never with hooked setae; mesothorax with a row of deep pits along its caudal margin with smooth quadrangular areas between, and partly covering them.

d. First abdominal segment with a small tubercle on each side of the meson at the cephalic margin of the segment; entire dorsal surface of the tenth segment distinctly elevated and very rugose; points of the cremaster divergent.

Hyparpax Hübner.

dd. First abdominal segment without tubercles; entire dorsal surface of the tenth segment not elevated and rugose.

e. Wings always touching on the meson; maxillae never as long as the wings; cephalic end of body sometimes with two sharp, heavily chitinized spinous projections.

Schizura Doubleday.

ee. Wings adjacent on the meson but not touching; maxillae usually as long as the wings; cephalic end of body without heavily chitinized spinous projections. .

Heterocampa Doubleday.

The following species were examined:

Melalophinae

Melalopha inclusa Hübner, *apicalis* Walker, *albosigma* Fitch

Apatelodinae

Apatelodes torrefacta Smith and Abbot, *angelica* Grote

Cerurinae

Harpyia borealis Boisduval

Pygaerinae

Datana ministra Drury, *modesta* Beutenmüller, *angusii* Grote and Robinson, *chiriquensis* Dyar, *contracta* Walker, *drexelii* Hy. Edwards, *integerrima* Grote and Robinson, *major* Grote and Robinson, *palmii* Beutenmüller, *robusta* Strecker

Notodontinae

Symmerista albifrons Smith and Abbot

Heterocampinae

Hyparpax aurora Smith and Abbot

Schizura ipomoeae Doubleday, *concinna* Smith and Abbot, *unicornis* Smith and Abbot

Heterocampa guttivitta Walker, *bilineata* Packard

Family Dioptidae

The pupae of this family closely resemble those of the Geometridae, but are more specialized than most of the genera in that family, although they show the epicranial suture (Fig. 115). The appendages are arranged very much as in the Geometridae, but there is no trace of labial palpi, maxillary palpi, or prothoracic femora (Fig. 114). The antennae are filiform, extending beyond the caudal margin of the wings and about half way down on to the fifth abdominal segment. Each prothoracic leg extends cephalad between the sculptured eye-piece and the antenna. The distal ends of the prothoracic and mesothoracic legs and the maxillae are overlaid by the antennae, which lie adjacent on the meson at their distal ends. The abdomen is elevated at the dorso-meson to form a low ridge, and there are prominent hooked setae present on segments seven to ten as well as on the cremaster. This family contains a single American species, *Phryganidia californica* Packard. The family has usually been placed between the Noctuidae and Notodontidae, and widely separated from the Geometridae. The pupa shows no relationship to the noctuids, and is much more highly specialized than most members of that family.

Superfamily SPHINGOIDEA

The members of this superfamily retain but one generalized character, the presence of exposed portions of the prothoracic femora in some of the more generalized forms. The shape of the pupa is almost as distinctive as that of the larva, being usually fusiform, often with the head distinctly narrower than the thorax, giving the body a "shouldered" appearance. The epicranial suture is never present, the only distinct head suture remaining being that adjacent to the proximal end of each antenna. The wings and maxillae are unusually long in most members of this superfamily and various means are taken to accomodate the extra length, particularly of the maxillae. The fourth abdominal segment is usually longer on the ventral surface than on the dorsal, and the wings are seldom broadly rounded at their caudal margins, but usually somewhat pointed. The position of the head is also changed in many species and found almost, or entirely, on the dorsal surface of the body. The mandibles are often very conspicuous, being represented by strongly elevated tubercles. The prothoracic legs are usually about half the length of the wings and the mesothoracic legs three fourths of their length. The metathoracic legs are seldom visible. The antennae are for the most part filiform and vary from two fifths to three fourths the length of the wings. In the genera Smerinthus, Paonias, Marumba, and Cressonia the antennae are considerably wider at their proximal end and slightly pectinate, being larger and longer in the male, and the whole appearance of the body reminds one strongly of the Saturniidae. These genera are in many respects the most specialized of the Sphingoidea, and some of them are found in cocoons. It is an interesting fact that the most specialized forms in nearly all of the subfamilies of Sphingidae examined, show relationship to the Saturniidae. This group is therefore considered as related to the Saturnioidea but more generalized. Certain of its members resemble in some respects the Pyralididae and Gelechiidae. A cremaster is always present, usually triangular in outline and often slightly bifurcate at the distal end. The abdomen often shows three or four transverse depressions on each segment which correspond to the annulet-like rings on the body of the larva. Except in rare instances the scar of the caudal horn of the larva is visible on the dorsum of the eighth abdominal segment.

This superfamily contains a single family, the Sphingidae. For the most part the genera are easily distinguished, but there were no characters found that served to separate the genera Smerinthus and Paonias. The generic names of Dyar's list have been used as far as possible. A monograph of this family, giving tables and descriptions

for the identification of subfamilies, genera, and species, has been prepared and will be published at an early date. The following table to genera is given simply for the identification of specimens and does not indicate natural relationships. The genera may be separated as follows:

a. Spiracular furrows present on all the movable segments, that is, on abdominal segments 5–7.
  b. Maxillae with a free portion or so-called "raised tongue-case" present—the maxillary loop.
    c. Maxillary loop with its distal half recurved and touching the proximal portion, forming a prominent loop on the ventral surface of the body. . . . . *Herse* Oken.
    cc. Maxillary loop never with the distal half recurved, the distal end touching the ventral surface of the body.
      d. Maxillary loop strongly arched from the ventral surface of the body, the greatest width of the space between the free portion of the maxilla and the ventral surface of the body always greater than the width of the maxillary loop in that region.
        e. Dorsum of body with a strongly rugose triangular area on each side of the meson of the metathorax and a similar rugose band on abdominal segments 2–8 extending over the cephalic third of the segment; lateral margins of the maxillary loop with a serrate appearance; the distal end of the loop swollen and bulb-like and at least twice the width of the remaining portion . . . . *Cocytius* Hübner.
        ee. Dorsum of body with a strongly elevated transverse ridge on each side of the meson on the metathorax, the abdominal segments punctate, but never rugose on the cephalic third; lateral margins of the maxillary loop never serrate in appearance; the distal end of the loop somewhat swollen but never twice the width of the remaining portion . . . . *Phlegethontius* Hübner.
      dd. Maxillary loop never strongly arched, but usually closely applied to the ventral surface of the body, the space between the loop and the ventral surface of the body never so great as the width of the loop in that region.
        e. Cephalic margin of abdominal segments 5–7 with one deep pocket-like furrow over each spiracle.
          f. Maxillary loop extending as far caudad as the distal ends of the prothoracic legs and occasionally beyond them. *Atreus* Grote.
          ff. Maxillary loop never extending as far caudad as the distal ends of the prothoracic legs . . . . *Dolba* Walker.
        ee. Cephalic margin of abdominal segments 5–7 with two furrows, the ectal furrow shallow, the ental one deep and pocket-like.

f. Spiracular furrows 5 mm. or more in transverse length and extending ventrad of the spiracle for a distance equal to the length of the spiracle. . . . . *Chlaenogramma* Smith.

ff. Spiracular furrows always less than 5 mm. in transverse length, seldom extending ventrad of the spiracle, if so, then for a distance less than the length of the spiracle. *Sphinx* Linnaeus.

bb. Maxillae of the usual type without a maxillary loop or so-called "raised tongue-case."

c. Cephalic margin of abdominal segments 5–7 always with one deep pocket-like furrow over each spiracle, with or without a shallow ectal one.

d. With one deep pocket-like furrow over each spiracle on abdominal segments 5–7.

e. Surface of body spinose; cremaster broad and truncate, the caudo-lateral angles usually produced into sharp points; caudal abdominal segments flattened on the ventral surface, and with distinctly carinate lateral margins. *Cressonia* Grote and Robinson.

ee. Surface of body never spinose; cremaster pointed, triangular in outline, caudal abdominal segments never flattened on the ventral surface, nor with distinctly carinate lateral margins.

f. Maxillae normally reaching to the caudal margin of the wings, slightly less in some individuals; mesothoracic wings never meeting on the meson caudad of the maxillae; scar of the caudal horn never present on the dorsum of the eighth abdominal segment. . . *Lapara* Walker.

ff. Maxillae never more than five sevenths the length of the wings; mesothoracic wings always meeting on the meson caudad of the maxillae; scar of the caudal horn always present on the dorsum of the eighth abdominal segment. *Daremma* Grote.

dd. With one deep pocket-like ental furrow and a shallower ectal one; maxillae about two thirds the length of the wings. *Ceratomia* Harris.

cc. Cephalic margin of abdominal segments 5–7 with three or four more or less interrupted furrows over each spiracle, the surface of the furrows often punctate like the remainder of the cephalic margin.

d. Maxillae never half the length of the wings; average length of maxillae at meson 5–6 mm., sometimes 7 mm. in large specimens; dorsal cephalic margin of abdominal segments 5–7 deeply punctate, the punctures adjacent to each other, giving it a honeycombed appearance, the cephalic margin separated

from the remainder of the segment by a distinct carinate ridge. {*Smerinthus* Latreille. *Paonias* Hübner.

dd. Maxillae half the length of the wings; average length of maxillae at meson 10 mm., sometimes exceeding this length; dorsal cephalic margin of abdominal segments 5–7 punctate, the punctures somewhat scattered and not presenting a honeycombed appearance; cephalic margin never separated from the remainder of the segment by a distinct ridge ....*Marumba* Moore.

aa. Spiracular furrows never present on all of the movable segments.

b. Spiracular furrows present on either one or two of the movable segments.

c. Cephalic margin of abdominal segments 5 and 6 with three or four furrows over each spiracle, the furrows separated by sharply carinate ridges and extending almost to the meson on both dorsal and ventral surfaces; cremaster sparsely covered with short curved spines on the dorsal and lateral aspects. *Hemaris* Dalman.

cc. Cephalic margin of fifth abdominal segment with three or more shallow furrows over each spiracle, which never extend on to the dorsal and ventral surfaces; cremaster never with short curved spines on any portion; labrum always on the dorsal surface of the head.

d. Prothoracic femora apparent.

e. Mandibular area always elevated and usually forming prominent tubercles; cephalic margin of fifth abdominal segment with one ental furrow over each spiracle, extending for the entire width of the lateral aspect, and five or six interrupted ectal furrows with interrupted carinate ridges between; body surface dull; color light brown or coffee-color with darker markings...............*Deilephila* Ochsenheimer.

ee. Mandibular area never elevated; cephalic margin of fifth abdominal segment with either three or four entire furrows over each spiracle; body surface highly polished; color black with red markings; abdominal segments finely punctate on the cephalic half....*Dilophonota* Burmeister.

dd. Prothoracic femora never apparent; cephalic margin of fifth abdominal segment with six or more interrupted furrows with short, more or less wavy interrupted ridges between; cephalic portion of maxillae slightly excurved and almost carinate on the meson; abdominal segments punctate over the entire length ....*Theretra* Hübner.

bb. Spiracular furrows never present on any of the movable abdominal segments.

c. Pupae always less than two inches in length; labrum usually at the cephalic end of the body but never on the dorsal surface.

d. Pupae with a prominent tubercle on the face-parts, just mesad of each glazed eye, and a prominent tubercle on the labrum; maxillae with the proximal portion excurved and carinate on the meson ....*Deidamia* Clemens.

dd. Pupae never with prominent tubercles on the face-parts or labrum; maxillae never with the proximal portion excurved and carinate on the meson.

e. Abdominal segments 5–7 with one or more interrupted rows of spines along the cephalic margin of the segment, more prominent on the dorsal surface........*Darapsa* Walker.

ee. Abdominal segments 5–7 never with spines along the cephalic margin of the segments.

f. Mandibular area with prominent tubercles.

g. Body surface rough, deeply punctate over the entire surface of the abdominal segments, especially segments 8–10; body tapering rapidly from the fourth abdominal segment to the long pointed cremaster; femora of prothoracic legs never apparent....*Amphion* Hübner.

gg. Body surface smooth and polished, the cephalic portion of the segment with punctures of medium size, the caudal portion finely, sparsely punctate; body tapering gradually from the fourth abdominal segment to cremaster; prothoracic femora apparent.
Lepisesia Grote.

ff. Mandibular area never elevated or with prominent tubercles.

g. Dorsum of eighth abdominal segment with a row of large deep punctures or pits along the cephalic margin; cremaster slender, never more than 2 mm. in length; body always light colored with darker markings ....*Ampelophaga* Bremer and Grey.

gg. Dorsum of eighth abdominal segment never with a row of large punctures or pits along the cephalic margin; cremaster always more than 2 mm. in length, the breadth equal to the length; body always dark brown.
Sphecodina Blanchard.

cc. Pupae always more than two inches in length; labrum either at the cephalic end or on the dorsal surface of the body.

d. Color black, often marked with red; body surface smooth and polished, with a very few small punctures on the abdominal segments; labrum at the cephalic end of the body.
Pseudosphinx Burmeister.

dd. Color uniform dark brown; body surface roughened and densely, coarsely punctate; labrum on the dorsal surface of the body, at least a distance equal to its own length away from the cephalic end of the body..........*Pholus* Hübner.

The following species were examined:

Herse cingulata Fabricius
Cocytius antaeus Drury
Phlegethontius quinquemaculata Haworth, *sexta* Johannsen
Atreus plebeia Fabricius
Dolba hylaeus Drury
Chlaenogramma jasminearum Boisduval
Sphinx kalmiae Smith and Abbot, *drupiferarum* Smith and Abbot, *gordius* Stoll, *lucitiosa* Clemens, *chersis* Hübner, *eremitus* Hübner
Cressonia juglandis Smith and Abbot
Lapara bombycoides Walker, *coniferarum* Smith and Abbot
Daremma catalpae Boisduval
Ceratomia amyntor Geyer, *undulosa* Walker
Smerinthus jamaicensis Drury, *cerysii* Kirby
Marumba modesta Harris
Hemaris diffinis Boisduval, *gracilis* Grote and Robinson, *thysbe* Fabricius
Deilephila lineata Fabricius
Dilophonota ello Linnaeus, *alope* Drury
Theretra tersa Linnaeus
Deidamia inscriptum Harris
Darapsa pholus Cramer
Amphion nessus Cramer
Lepisesia gaurae Smith and Abbot, *juanita* Strecker
Ampelophaga myron Cramer, *versicolor* Harris
Sphecodina abbotti Swainson
Pseudosphinx tetrio Linnaeus
Pholus pandorus Hübner, *achemon* Drury

Superfamily SATURNIOIDEA

The pupae of this superfamily retain none of the generalized characters found in the families previously discussed and all the sutures of the head are obliterated, even those adjacent to the proximal ends of each antenna. The body is usually heavily chitinized, and although there are always a few setae present they are rarely visible to the unaided eye. The superfamily is distinguished by the presence of broadly pectinate antennae, in the Ceratocampidae for about one third of the length, while in the Hemileucidae and Saturniidae they are broadly pectinate to the distal end, and generally have the stem of the flagellum elevated. The greatest width of each antenna is at least one fifth

of its length, often much wider, and the antennae seldom extend farther caudad than the prothoracic legs. There is a marked difference in the sexes, the antennae of the male being much broader, somewhat longer, and often meet on the meson, covering nearly all of the appendages except the wings. The legs are shorter than in most superfamilies, the prothoracic and mesothoracic legs usually either meeting or lying adjacent on the meson. The maxillae never reach the caudal margin of the wings, and their greatest length is not more than one third the length of the wings, but they are usually much shorter. The mesothoracic wings always lie adjacent on the meson and the metathoracic wings are often visible on the meson in the Saturniidae. The family Ceratocampidae has a row of broad triangular spines set on the edge of a flanged plate along both cephalic and caudal margins of the movable abdominal segments. They usually possess very long cremasters, which are always bifurcate at the distal end. The Hemileucidae have short cremasters, while there are none present in the Saturniidae and few of the genera have spines at the caudal end of the body.

A paper on this superfamily, giving tables for the identification of families, genera, and species has been prepared and the first part, "The Classification of the Pupae of the Ceratocampidae and Hemileucidae," was published in the Annals of the Entomological Society of America, Vol. 7, 1914, pp. 277–300. The manuscript for the remainder is now in the hands of the editor of the same journal. The following tables of families and genera and the descriptions, with some slight additions and corrections, are taken from the paper mentioned above. The generic names in Dyar's list are used, but the genera are not arranged to indicate natural relationships. The superfamily Saturnioidea may be divided into three families as follows:

a. Pupae with the movable segments provided with flange-like plates which prevent their being telescoped, their lateral margins distinctly tapering caudad and each segment noticeably smaller than the segment cephalad of it; wings never elevated dorsad above the surface of the body; a distinct cremaster always present; stem of the flagellum of the antenna never elevated and distinct.

b. Pupae with a distinctly bifurcate cremaster; body usually roughened with spines on the exposed surface of the thorax and abdomen; metathorax with prominent oblong tubercles on each side of the meson extending one third or more of the distance between the meson and the margin of the first pair of wings; pupae always found in the ground........................CERATOCAMPIDAE.

bb. Pupae without a distinctly bifurcate cremaster; body never roughened with spines on the exposed surface of the thorax and

abdomen; metathorax never with prominent oblong tubercles; pupae found either in cocoons or in the ground. . HEMILEUCIDAE.

aa. Pupae with the movable segments never provided with flange-like plates which prevent their being telescoped, the lateral margins approximately parallel so that the segments appear of equal size and are usually telescoped so that only the caudal margins of the segments are visible; wings prominently elevated dorsad above the level of the body, the caudal portion of the mesonotum and metanotum always depressed adjacent to the wings; a distinct cremaster rarely present; stem of the flagellum of the antenna always elevated and distinct ....SATURNIIDAE.

Family HEMILEUCIDAE

Margins of the free segments never with a row of spines; the body surface never roughened with spines; antennae with the stem of the flagellum never distinct, the central axis never set with spines, the antennae tapering gradually from the part having the greatest width; maxillae never more than one sixth the length of the wings; proleg scars seldom prominent on abdominal segments five and six and rarely with the anal proleg scars visible; mesothoracic wings with the anal angles broadly rounded, usually at the cephalic margin of fourth abdominal segment, and usually reaching the caudal margin of the fourth abdominal segment ventrally; metathoracic wings never produced below the anal angles of the first pair of wings and never visible in ventral view; metathorax never with prominent tubercles; abdominal segments 5 to 7 with the cephalic margin produced into a thick oblique flange-like plate directed caudad; cremaster short, never bifurcate at tip.

Although not usually included with the Hemileucidae the genus Automeris is placed in this group owing to the very evident relation of the pupae to those of the genera Hemileuca and Pseudohazis. Morphologically they seem to be more nearly related to the Hemileucidae, but they are found in cocoons like the Saturniidae. Some of the members of this family pupate in the ground.

The description of this family is of necessity very incomplete owing to lack of material. According to our available knowledge of the subject the three genera may be separated as follows:

a. Cremaster bearing setae arranged in a tranverse row and spreading out fan-like....................*Pseudohazis* Grote and Robinson.

aa. Cremaster never with setae, either with curved spines or without spines or setae of any kind.

b. Cephalic part of segment above the flange-like plate either smooth or with fine longitudinal striations; pupae found in ground. *Hemileuca* Walker.

bb. Cephalic part of segment above the flange-like plate with sharp transverse ridges, deep furrows between; pupae found in cocoons .... *Automeris* Hübner.

The following species were examined:
Pseudohazis eglanterina Boisduval
Hemileuca maia Drury, *burnsi* Watson, *olivae* Cockerell
Automeris pamina Neumoegen, *io* Fabricius, *leucana* Hübner, *incarnata* Walker

Family CERATOCAMPIDAE

Body with the margins of the free abdominal segments usually bearing a row of spines, and the exposed surface of the thorax and abdomen usually roughened with spines; antennae never broadly pectinate throughout, but broadly pectinate and almost parallel for about one half the length, then narrowed rapidly to about half the greatest width, tapering gradually to a pointed tip, the stem of the flagellum never distinct, the surface convex and the central axis of the antenna usually bearing one or two rows of small spines; maxillae never less than one fourth the length of the wings; tips of the mesothoracic tarsi meeting obliquely on the meson, never lying adjacent on the meson; proleg scars very prominent on abdominal segments five and six, the scars for the anal prolegs often very conspicuous; mesothoracic wings with the anal angles broadly rounded, usually located at the cephalic margin of the fourth abdominal segment and never reaching ventrad to the caudal margin of the fourth segment; metathoracic wings never produced below anal angle of the mesothoracic wing and never visible in ventral view; metathorax with distinct tubercles, more or less oblong in outline, on each side the meson and extending more than one third the distance from the meson to the margin of the wing; the suture between the seventh and eighth segments never deep, or with distinct crenulations on its margins; cremaster always present, usually long and bifurcate at tip. Five genera of this family have been described. One genus, Syssphinx, consisting of three species, was not available for study. The pupae of this family are always found in the ground. The remaining genera of Ceratocampidae can be separated by the following table:

a. Surface of pupa never spinose; cremaster broader than long, broadly and shallowly bifurcate, never over 2 mm. in length.
Citheronia Hübner.

aa. Surface of pupa spinose; cremaster at least twice as long as broad, bifurcate at tip, always more than 2 mm. in length.

b. Thorax rugose with short isolated spines, abdominal segments not spinose, but bearing a row of spines along both cephalic and caudal margins of segments 1–7, the spines along the caudal margin of segments 5–7 much longer than the spines of the cephalic row .... *Basilona* Boisduval.

bb. Thorax and abdominal segments densely spinose; abdominal segments 1–7 with a row of spines along both cephalic and caudal margins, the spines in the cephalic row on abdominal segments 5–7 usually much longer than the spines in the caudal row; maxillae, measured on meson, one fourth the length of the wings.

c. Usually with prominent scattered spines on the thoracic segments, at least four times as long as those covering the segments; antennae with the central axis bearing a row of prominent spines curved caudad; if without prominent spines on the thoracic segments and antennae, then the maxillae are one third the length of the wings.

d. Eighth abdominal segment never with a prominent transverse ridge in the middle of the segment bearing a row of spines; glazed eye-piece always lighter in color than the remaining surface of the body; species always more than an inch in length .... *Adelocephala* Herrich-Schaeffer.

dd. Eighth abdominal segment always with a prominent transverse ridge in the middle of the segment bearing a row of spines; glazed eye-piece always the same color as the remaining surface of the body; species never more than an inch in length .... *Dryocampa* Harris.

cc. Without prominent scattered spines on the thoracic segments, the longest never four times the length of those covering the segments; antennae with the central axis never bearing prominent spines, the spines never curving caudad; maxillae always one fourth the length of the wings.......... *Anisota* Hübner.

The following species were examined:

Citheronia regalis Fabricius
Basilona imperialis Drury
Adelocephala bicolor Harris, *bisecta* Lintner
Dryocampa rubicunda Fabricius
Anisota virginiensis Drury, *stigma* Fabricius, *senatoria* Smith and Abbot, *skinneri* Biederman, *consularis* Dyar

Family Saturniidae

The members of this family have the antennae broadly pectinate throughout, or nearly so, and the stem of the flagellum is usually distinct and raised above the level of the pectinations. The maxillae are always short, never more than one third the length of the wings, and

usually very much shorter. The tibiae and tarsi of the prothoracic legs, and the tarsi of the mesothoracic legs lie adjacent on the meson, but never meet obliquely on the meson as they do in the ceratocampids. The mesothoracic wings always have their anal angles broadly rounded and the wings always reach the caudal margin of the fourth abdominal segment on the ventral surface. The metathoracic wings are produced around the anal angles of the mesothoracic wings and usually form prominent angles on the fourth abdominal segment. The metathoracic wings always extend for at least a short distance along the caudal margin of the mesothoracic wings on the ventral surface of the body. The metathorax never has distinct oblong tubercles which are one third or more the width of the segment, such as are found in ceratocampids. The suture between the seventh and eighth abdominal segments is never deep, with distinct crenulations on its margins, and is indistinct in many species. The cremaster, if present, is very short and is never bifurcate at the distal end.

The known pupae of members of this family are found in silken cocoons. Some of these are very thick and tough, others thin and papery. Only nine genera of this family have been available for study. These may be separated by the following table:

a. Lateral margins of abdominal segments 5–7 never approximately parallel, but tapering from the cephalic margin of the fifth segment, the lateral margins usually distinctly convex; caudal end of body usually with stout curved spines.

b. Tenth abdominal segment never flattened into a transverse plate with the caudo-lateral angles produced into short lobes.

c. Caudal end of body without spines; body surface with slightly wavy, transverse ridges with distinct furrows between; mesothorax never with a prominent tubercle at the base of each wing. *Copaxa* Walker.

cc. Caudal end of body with stout curved spines; body surface never with slightly wavy, transverse ridges with distinct furrows between; mesothorax with a prominent tubercle at the base of each wing.

d. Lateral aspects of the cephalic margin of abdominal segments never with spiracular furrows; caudal end of body with an oval area set with slightly curved spines arranged in two groups and nearly all pointing outwards......*Telea* Hübner.

dd. Lateral aspects of the cephalic margin of abdominal segments 5–7 with spiracular furrows separated by slightly wavy carinate ridges; caudal end of body deeply rugose, with a slight concavity containing a circular group of strongly recurved spines................*Tropaea* Hübner.

bb. Tenth abdominal segment, viewed dorsally, in the form of a transverse plate, concave on the caudal margin, the caudo-lateral angles produced into lobes; the other segments strongly concave in ventral view, with five short curved spines inserted close together in the caudo-lateral margin of each lobe.
Agapema Neumoegen and Dyar.

aa. Lateral margins of abdominal segments 5–7 always approximately parallel, the caudal end of the body never with stout curved spines.

b. Maxillae always one fourth, or less, the length of the wings, the proximal two thirds of their margins never strongly concave; mesothoracic wings with their anal angles on the cephalic margin of the fourth abdominal segment or caudad of that portion of the segment.

c. Maxillae less than one fifth the length of the wings; antennae of males with the sides tapering gradually to a pointed tip.

d. Both eye-pieces never visible in either sex; glazed eye-piece seldom visible in the females, never in the males; caudal end of abdomen never with a band of coarse setae.

e. Eye-pieces never visible in either sex; caudal end of abdomen never with spines or setae........*Callosamia* Packard.

ee. Glazed eye-piece visible in the females; caudal end of abdomen with a few very short sharp spines.
Eupackardia Cockerell.

dd. Both eye-pieces visible in either sex; caudal end of abdomen with a transverse band of coarse setae..*Rothschildia* Grote.

cc. Maxillae never less than one fifth the length of the wings; antennae of males with the sides approximately parallel for the greater part of their length, tapering rapidly to a blunt rounded tip; a small portion of glazed eye-piece always visible in the females ....*Samia* Hübner.

bb. Maxillae always more than one fourth the length of the wings; the proximal two thirds of the lateral margins of the maxillae concave; first pair of wings with their anal angles on the third abdominal segment opposite the second pair of abdominal spiracles ....*Philosamia* Grote.

The following species were examined:

Copaxa lavendera Westwood
Telea polyphemus Cramer
Tropaea luna Linnaeus
Agapema galbina Clemens
Callosamia promethea Drury, *angulifera* Walker
Eupackardia calleta Westwood
Rothschildia orizaba Westwood, *jorulla* Westwood
Samia cecropia Linnaeus, *gloveri* Strecker, *columbia* Smith, *rubra* Behr
Philosamia cynthia Drury

Phylogeny

The characters used as a basis for determining the phylogeny of the order are primarily: (1) the number of movable segments; (2) the freedom of the appendages; (3) the number of sutures present in the head; (4) the relative length of the body segments; (5) the presence or absence of visible labial palpi and maxillary palpi; (6) the presence of exposed portions of the prothoracic femora in specialized pupae; and (7) the method of dehiscence.

In the most generalized forms there is complete freedom of motion possible between the head and thorax, and between all the segments of the thorax and abdomen with the exception of the eighth, ninth, and tenth abdominal segments, which are always fixed. As specialization proceeds, there is a gradual loss of motion; first between the head and thorax, then between the segments of the thorax, and last of all between the different segments of the abdomen. The loss of motion in the abdomen begins first at the cephalic end, but by the time that complete motion of the second segment has been lost there begins a loss of motion of the seventh segment. This takes place first in the female, and there is a large series of forms, including the superfamilies Gracilarioidea, Tortricoidea, and Aegerioidea, which retain freedom of motion in the seventh segment of the male, while there is taking place at the cephalic end of the abdomen the loss of motion of the third abdominal segment. There are, however, a few genera of Gracilarioidea which have lost freedom of motion of all the body segments and which form the most specialized end of that series. The pupae which have lost motion of all the abdominal segments except the fourth, fifth, and sixth, are those usually referred to as obtected pupae. There are few pupae more specialized than those of the superfamily Gracilarioidea which retain freedom of motion of the seventh abdominal segment in the male, but there are a few generalized forms both in the Pyralidoidea and Papilionoidea in which this is the case, as it is also in the family Epermeniidae of the Yponomeutoidea. These three superfamilies are usually considered as more specialized than the Gracilarioidea. As the number of movable segments determines the position of a superfamily in the series it is readily seen that these superfamilies must be considered as more generalized than those in which motion is lost in the seventh segment in the male. It will be remembered that a segment is spoken of as movable when motion is possible between its caudal margin and the segment caudad of it. As the appendages become soldered to the body wall on the ventral surface no motion of this part of the segment is possible if the incision between its caudal margin and the next seg-

ment is covered by the wings, therefore it can not be considered as a free segment. In many cases, however, dorsal movement of such segments is possible, which gives the segment freedom of movement in certain directions; as, for instance, in curving the caudal end of the body cephalad on the ventral surface, well illustrated in the movements of most tortricids. Such forms must be considered as more generalized than those which have lost entire motion of the segment, and thus the Pyralidoidea and Papilionoidea must occupy a lower position than the Yponomeutoidea, whose members have lost dorsal motion of the third abdominal segment, while the other two superfamilies mentioned retain it. There are certain specialized forms in other superfamilies in which motion is lost in all the body segments, notably in the family Elachistidae of the Gelechioidea and in certain genera of the family Nymphalidae in the Papilionoidea. There are also many genera in various families which retain movement in only one segment.

The appendages of the generalized pupae are entirely free from each other and from the body wall and are often considerably spread out from the surface of the body so that the pupae strongly resemble those of the Trichoptera. In these forms there is but a slight degree of chitinization in any part of the body. The appendages are gradually soldered down, however, first to each other, while all remain free from the body wall, and then there takes place a gradual soldering down of the appendages to the body wall, beginning first at the cephalic end of the abdomen. In many pupae the appendages are soldered to two, three, or four abdominal segments while the portion of the appendages caudad of these segments remains free and allows freedom of motion of the abdominal segments underneath. Such a condition exists in many genera of the Aegerioidea and Gelechioidea. The pupae with free appendages could only exist successfully in protected situations from which an easy egress was possible, and so they are only found in cocoons, or in mines in leaves and stems of plants. Pupae with any other environment lost the freedom of the appendages much more rapidly, as in the case of the Lyonetiidae and some of the Papilionoidea.

The number and arrangement of the sutures present on the head has already been discussed under the head of external morphology, pages 23 to 25. These sutures are gradually obliterated, beginning with the clypeo-labral, which is lost among very generalized pupae. The epicranial suture is one of the last to disappear, and its presence indicates the degree of specialization in many of the higher forms, as it is retained in some members of many superfamilies which are high in the series.

The fronto-clypeal suture is visible for a part of its length in most pupae, and is especially distinct for its entire length in some of the Gelechioidea; but dehiscence often showed the presence of this suture when it was impossible to locate it on the pupa. The part of this suture adjacent to the proximal end of each antenna is the last head suture to be obliterated, and it is lacking only in the Saturnioidea.

The segments of the body are more nearly of equal length in generalized than in specialized forms, especially in the abdomen. The prothorax is short in the Micropterygoidea and becomes gradually longer in the specialized superfamilies. The metathorax is long in generalized forms and nearly equals the mesothorax in length. As specialization proceeds, the mesothorax becomes longer and the metathorax much shorter, so that the comparative length of these two segments furnishes another means of determining the position of a superfamily in the series. The abdominal segments also become consolidated, first at the caudal end of the body, where they gradually become shorter than the cephalic segments. After motion is lost in the cephalic segments, they, too, gradually shorten, until the movable segments are much longer than any of the others.

The presence of visible maxillary and labial palpi also furnishes an easy means for the identification of generalized forms. The labial palpi are retained throughout the series, but are gradually overlaid and concealed by the maxillae. The presence or absence of visible labial palpi, however, indicates the degree to which specialization has proceeded along a given line. Labial palpi are visible to some extent in some members of all superfamilies except the Saturnioidea. The maxillary palpi are usually the first to disappear, but these palpi are often present in the pupa, when lacking in the imago. The maxillary palpi in generalized forms reach the proximo-lateral angles of the maxillae, but gradually decrease in length until they are visible only as a small triangular area caudad of the sculptured eye-piece.

When the appendages are free their position is considerably laterad of that which they gradually assume as they become soldered to each other. The legs are folded in such a way that in generalized forms almost the entire femur of the prothoracic leg is exposed. Later the tibia and tarsus of this leg are folded so that their position is nearer the meson than formerly and the femur is entirely concealed. The presence of an exposed portion of the prothoracic femur is a generalized condition which is retained by forms exceedingly specialized in other respects, and is found in some genera of Sphingidae.

As to the method of dehiscence, there are several things to be noted, although all too little is known of this interesting phase of pupal

life. There is a tendency for the generalized forms to emerge from the mine, cocoon, burrow, or other place of protection, as a pupa, and consequently the body is provided with some structure which assists in its progress. The appendages and body segments are usually separated from each other at dehiscence and the body splits along the median line of the vertex and thoracic segments, the vertex carrying the sculptured eye-pieces with it. The front, with the antennae, is completely separated from the rest of the head parts in some forms, by a splitting along the epicranial suture on the dorsum, and along the fronto-clypeal suture on the ventral surface. When the fronto-clypeal suture is not entire it usually splits for a part of its length, thus allowing it to be considerably elevated. In specialized forms it is usually the imago which emerges, the pupal skin being left behind in the cocoon or other place of protection. The appendages and body segments remain firmly soldered together and the imago escapes through the opening made by the splitting of the vertex, when present, the prothorax, and the mesothorax; or, if this is not sufficient, an irregular opening which does not follow the line of any suture is made in the cephalic end of the body. In these forms the eye-pieces remain attached to the other face-parts.

The phylogeny of any group is usually determined by the development of a single character. Many workers have used the venation of the wings to arrange a series of genera or species in phylogenetic order. Others have used the genitalia, or the arrangement of setae. The pupae present many and varied characters which may be used to arrange such a series. In this investigation a series was arranged for each of the characters previously mentioned and the results of these series were combined. These characters have the advantage over those used by previous authors in that they comprise practically all of the important structures of the body and are all present in the same individual. It is quite probable that other characters might be used to indicate the development of the order, such as the number and arrangement of the genital apertures, the form of the spiracles, and the arrangement of setae, none of which have been investigated sufficiently to admit of their use in this paper.

Acknowledgments

The subject for this investigation was suggested by Professor A. D. MacGillivray in September, 1912. Since that time many species of Lepidoptera have been collected, both in the larval and pupal stage, and reared to maturity. The Graduate School of the University of

Illinois has made liberal appropriations for the purchase of material, and a large series of named pupae has been obtained from the following sources: the American Entomological Company, Ward's Natural Science Establishment, the Kny-Scheerer Company, the New England Entomological Exchange, the New Jersey Entomological Company, and from Mr. Wm. Beutenmüller, A. H. Manee, of Southern Pines, N. C., E. J. Oslar, of Denver, Colo., and Miss Annette F. Braun, of Cincinnati, Ohio. Dr. L. O. Howard, Chief of the Bureau of Entomology of the U. S. Department of Agriculture, Mr. August Busck, of the U. S. National Museum, and Dr. Wm. Barnes, of Decatur, Ill., have furnished a number of rare species which contributed in no small measure to the progress of the investigation. The collections of the Illinois State Laboratory of Natural History have been freely available, and for this courtesy Professor S. A. Forbes deserves our hearty thanks as well as his assistants, Mr. J. R. Malloch and Mr. C. A. Hart. Dr. T. H. McDunnough, of Decatur, Ill., and Miss A. F. Braun have assisted in the identification of bred material, thus making available many species that otherwise could not have been used. The collections furnished by Miss Braun and Mr. Beutenmüller deserve especial mention. Miss Braun collected, bred, and determined more than one hundred species of the so-called Microlopidoptera which really formed the working basis for this part of the investigation. Most of the work done on the Sphingidae has been from specimens furnished by Mr. Beutenmüller, who has collected a large series of forms. Mr. Samuel Henshaw, of the Museum of Comparative Zoology at Harvard, very kindly loaned a large series of Papilionoidea, most of which were collected by Dr. S. H. Scudder and described in his "Butterflies of the Northern United States and Canada." Professor J. G. Needham, of the Department of Entomology at Cornell University, also loaned a large number of species from the collections of that University, which were especially valuable and could not be obtained elsewhere.

It would be impossible in this brief space to enumerate the many ways in which Professor MacGillivray has assisted in the preparation of this paper. His interest in the work has been unfailing, and whatever of value it may contain is due to his inspiration, encouragement, and helpful criticism.

Bibliography

Chapman, T. A.

'93. Some neglected points in the pupae of the heterocerous Lepidoptera. Trans. Ent. Soc. London, 1893 : 97–119.

'93. On a lepidopterous pupa (Micropteryx purpurella) with functionally active mandibles. Trans. Ent. Soc. London, 1893 : 255–265.

'94. Some notes on the Microlepidoptera whose larvae are external feeders. Trans. Ent. Soc. London, 1894 : 335–350.

'96. Notes on pupae—Orneodes, Epermenia, Chrysocorys and Pterophorus. Trans. Ent. Soc. London, 1896 : 129–147.

Jackson, W. Hatchett.

'91. Morphology of the Lepidoptera. Trans. Linn. Soc. London, Zool., Ser. 2, Vol. 5.

Packard, A. S.

'95. Attempt at a new classification of the Lepidoptera. Monograph of the Bombycine moths of America north of Mexico, Part I. Memoirs of the National Academy of Sciences, 7 : 56–83.

Poulton, E. B.

'91. The external morphology of the lepidopterous pupa. Trans. Linn. Soc. London, Zool., Ser. 2, 5 : 245–263.

Scudder, S. H.

'89. The butterflies of the Eastern United States and Canada. 3 vols.

Tutt, J. W.

'00. A natural history of the British Lepidoptera, 2 : 38–100.

Plates

The following plates show in outline the principal structures of pupae of many of the families discussed in this paper. No attempt has been made to show all of the setae, spines, or tubercles which may occur, but only those which are most important and are of taxonomic value.

The following abbreviations have been used:

a,	antennae
a1–a10,	abdominal segments 1–10
af,	alar furrow
ao,	anal opening
ar,	anal rise
at,	invaginations for the anterior arms of the tentorium
cl,	clypeus
cls,	clypeo-labral suture
cdm,	caudal margin of an abdominal segment
cm,	cephalic margin of an abdominal segment
cr,	cremaster
cs,	cremastral setae
cx1,	coxa of the prothoracic leg
cx2,	coxa of the mesothoracic leg
cx3,	coxa of the metathoracic leg
dlt,	dorso-lateral row of tubercles
dmt,	dorso-mesal row of tubercles
dst,	dorso-spiracular row of tubercles
es,	epicranial suture
f,	front
fcs,	fronto-clypeal suture
f1	femur of the prothoracic leg
f2,	femur of the mesothoracic leg
fp,	flanged plate
g,	genae
ge,	glazed eye-piece
go,	genital opening
lb,	labrum
l_1,	prothoracic leg
l_2,	mesothoracic leg
l_3,	metathoracic leg
lp,	labial palpi
md,	mandibles
mp,	maxillary palpus
ms,	mesothorax
msp,	mesothoracic spiracle
mt,	metathorax
mx,	maxilla
p,	prothorax
pf,	pilifer
psc,	proleg scar
s,	spiracle
se,	sculptured eye-piece
sf,	spiracular furrow
t,	tegulae
ts,	tubercle scar
v,	vertex
vst,	ventro-spiracular row of tubercles
w1,	mesothoracic wing
w2,	metathoracic wing

INDEX TO GENERA AND HIGHER GROUPS

F

G

H

I

J

L

M

Plate XIX

Fig. 1. Mnemonica auricyanea, ventral view, male.
Fig. 2. Mnemonica auricyanea, lateral view, female.
Fig. 3. Mnemonica auricyanea, dorsal view, female.
Fig. 4. Mnemonica auricyanea, dorsal view, caudal end of abdomen, male.
Fig. 5. Mnemonica auricyanea, ventral view, caudal end of abdomen, male.
Fig. 6. Mnemonica auricyanea, dorsal view, caudal end of abdomen, female.
Fig. 7. Mnemonica auricyanea, ventral view, caudal end of abdomen, female.
Fig. 8. Sthenopis thule, ventral view, male.
Fig. 9. Sthenopis thule, lateral view, male.
Fig. 10. Sthenopis thule, dorsal view, male.
Fig. 11. Thyridopteryx ephemeraeformis, ventral view, male.
Fig. 12. Thyridopteryx ephemeraeformis, lateral view, male.
Fig. 13. Thyridopteryx ephemeraeformis, dorsal view, male.
Fig. 14. Thyridopteryx ephemeraeformis, ventral view, female.
Fig. 15. Prionoyxstus robiniae, face-parts, male.
Fig. 16. Zeuzera pyrina, ventral view, male.

Plate XIX

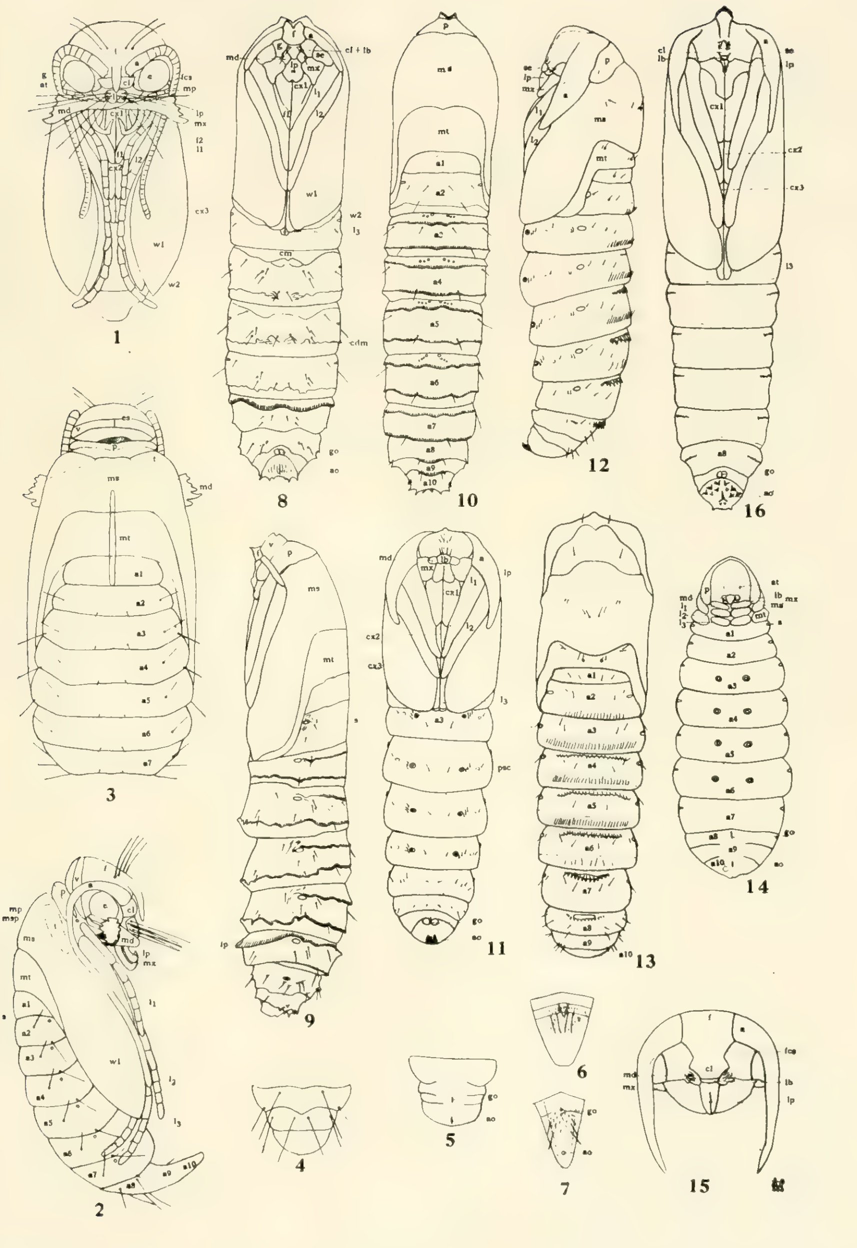


Plate XX

Fig. 17. Lagoa crispata, ventral view, female.
Fig. 18. Lagoa crispata, dorsal view, female.
Fig. 19. Euclea chloris, ventral view, female.
Fig. 20. Euclea chloris, dorsal view, male.
Fig. 21. Euclea chloris, mesothoracic spiracle and adjacent parts.
Fig. 22. Euclea chloris, cephalic view of head and prothorax.
Fig. 23. Prolimacodes scapha, ventral view, male.
Fig. 24. Harrisina americana, ventral view, female.
Fig. 25. Harrisina americana, dorsal view, female.
Fig. 26. Prodoxus quinquepunctella, face-parts.
Fig. 27. Prodoxus quinquepunctella, lateral view.
Fig. 27a. Prodoxus quinquepunctella, tubercle of the eighth abdominal segment, lateral view.
Fig. 28. Hypocolpus mortipennellus, ventral view, female.
Fig. 29. Hypocolpus mortipennellus, dorsal view, female.
Fig. 30. Tinea pellionella, ventral view, male.
Fig. 31. Tinea pellionella, dorsal view, male.

Plate XX

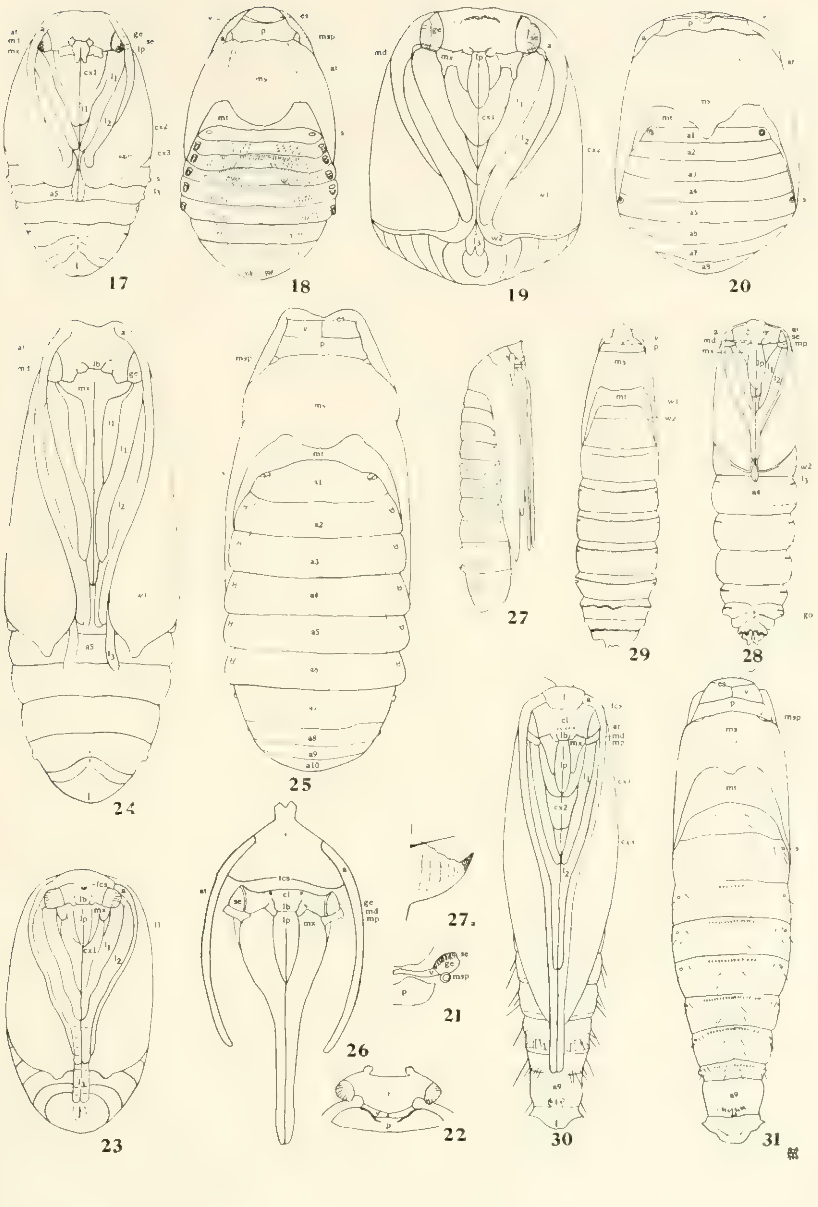


Plate XXI

Fig. 32. Brenthia pavonacella, ventral view, female.
Fig. 33. Brenthia pavonacella, dorsal view, male.
Fig. 34. Choreutis gnaphiella, ventral view, female.
Fig. 35. Choreutis gnaphiella, dorsal view, female.
Fig. 36. Podosesia syringae, ventral view, female.
Fig. 37. Synanthedon pictipes, dorsal view, head, thorax and abdominal segments 1–3.
Fig. 37a. Synanthedon pictipes, dorsal view, abdominal segments 8–10.
Fig. 38. Ancylis comptana, ventral view, male.
Fig. 38a. Ancylis comptana, anal rise, lateral view.
Fig. 39. Ancylis comptana, dorsal view, male.
Fig. 40. Exartema ferriferanum, ventral view, male.
Fig. 41. Peronea minuta, lateral view, male.

Plate XXI

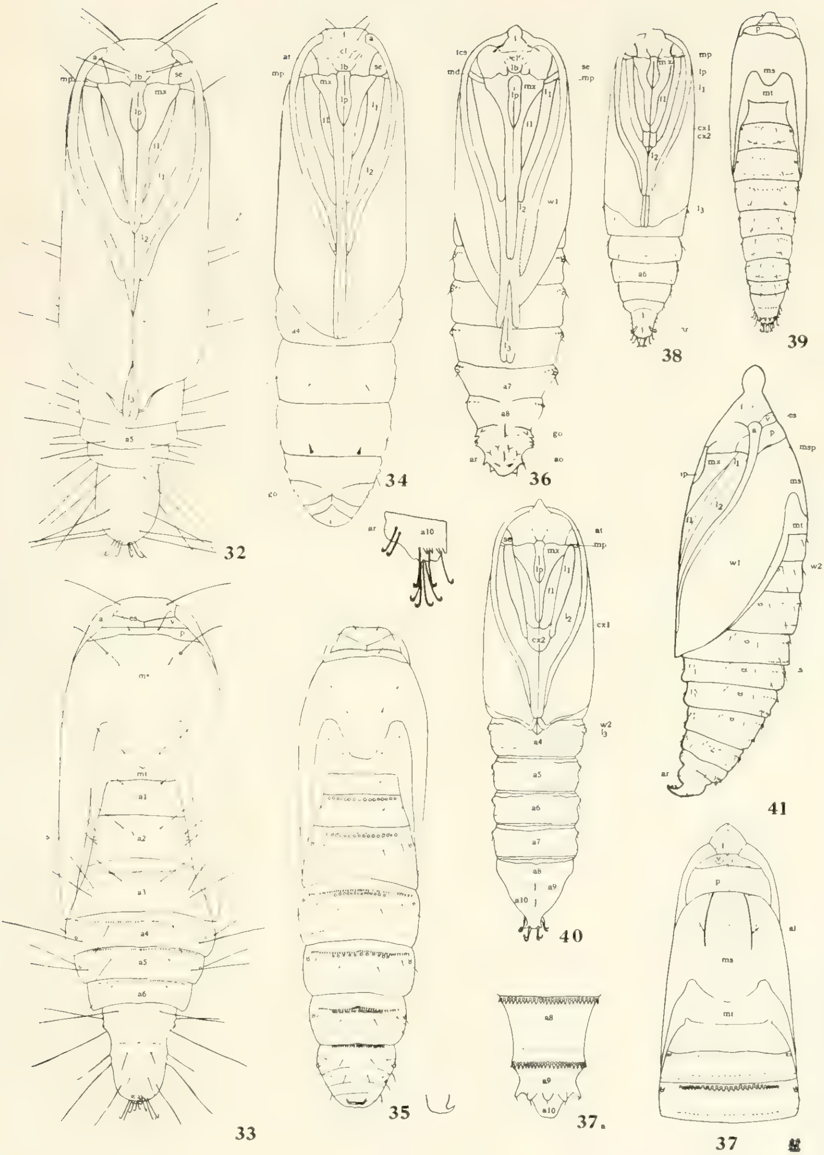


Plate XXII

Fig. 42. Peronea minuta, ventral view, female.
Fig. 43. Peronea minuta, showing the connection of the eye-pieces with the vertex after removal of antennae at dehiscence.
Fig. 44. Archips argyrospila, ventral view, female.
Fig. 45. Gracilaria negundella, ventral view, male.
Fig. 46. Gracilaria negundella, terminal segments of antenna.
Fig. 47. Gracilaria sassafrasella, cephalic end of prothoracic and mesothoracic legs, with adjoining area supposed to be the location of the maxillary palpus.
Fig. 48. Nepticula platanella, ventral view, male.
Fig. 49. Nepticula platanella, dorsal view, male.
Fig. 50. Antispila cornifoliella, ventral view, male.
Fig. 51. Coptotriche zelleriella, ventral view, male.
Fig. 52. Coptotriche zelleriella, dorsal view, male.
Fig. 52a. Coptotriche zelleriella, lateral view, caudal end of abdomen.
Fig. 52b. Coptotriche zelleriella, tips of strongly chitinized setae.
Fig. 53. Tischeria malifoliella, dorsal view, female.

PLATE XXII

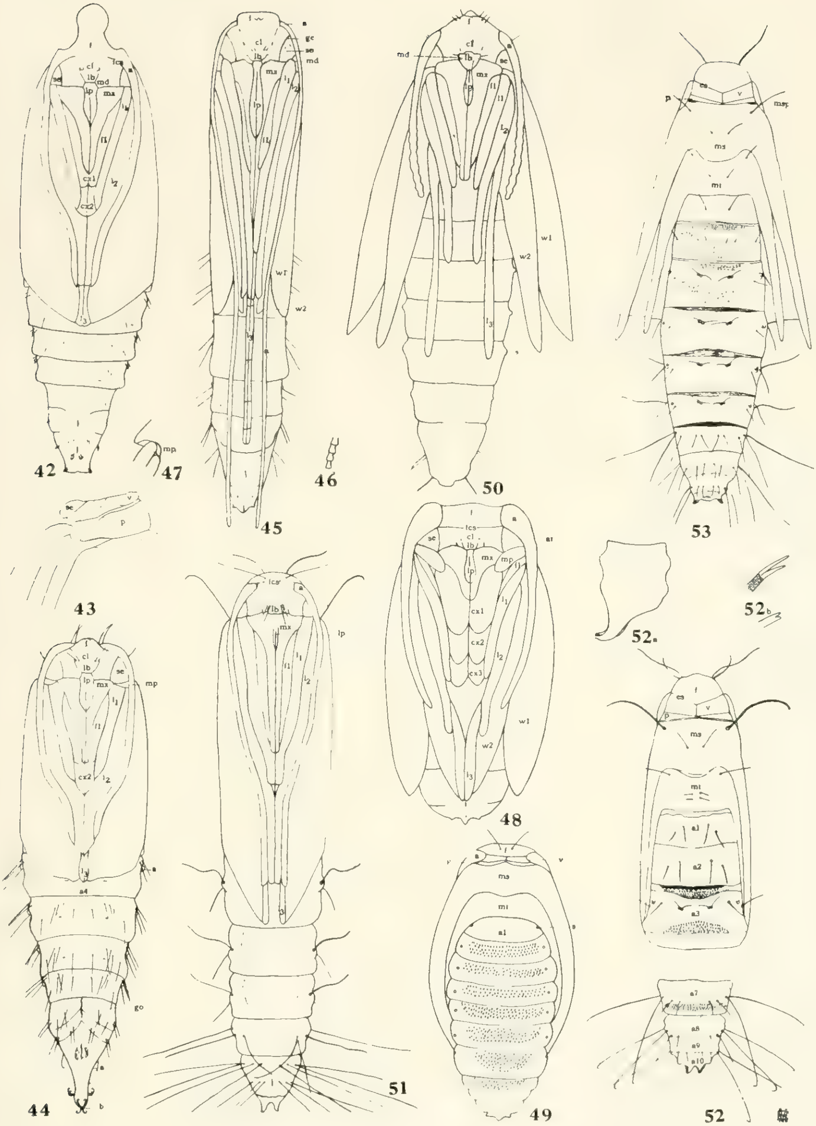
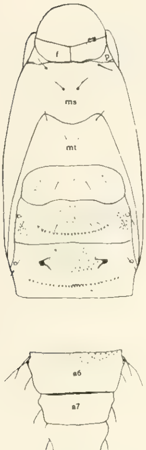


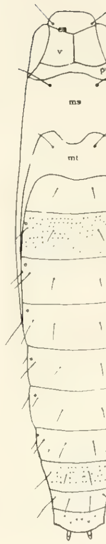
Plate XXIII

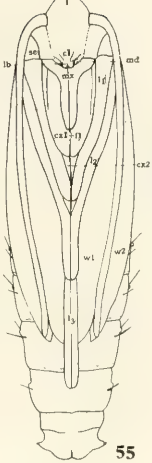
Fig. 54. Tischeria heliopsisella, dorsal view, male.
Fig. 54a. Tischeria heliopsisella, lateral view, caudal end of abdomen.
Fig. 55. Bucculatrix sp., ventral view, male.
Fig. 56. Bucculatrix sp., dorsal view, female.
Fig. 56a. Bucculatrix sp., lateral view of head.
Fig. 57. Bedellia somnulentella, ventral view.
Fig. 58. Bedellia somnulentella, dorsal view.
Fig. 59. Proleucoptera smilaciella, ventral view.
Fig. 60. Proleucoptera smilaciella, dorsal view.
Fig. 61. Cameraria hamadryadella, ventral view, male.
Fig. 62. Cameraria hamadryadella, dorsal view, male.
Fig. 62a. Cameraria hamadryadella, lateral view, head.
Fig. 62b. Cameraria hamadryadella, dorsal view fifth and sixth abdominal segments, female.
Fig. 63. Gracilaria negundella, dorsal view, male.

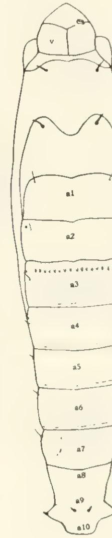
Plate XXIII


54

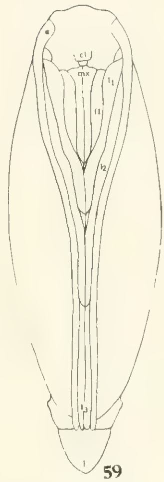

54a

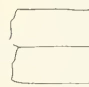

63

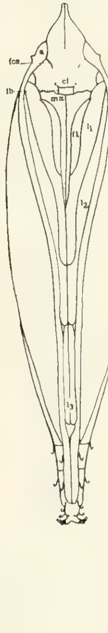

55

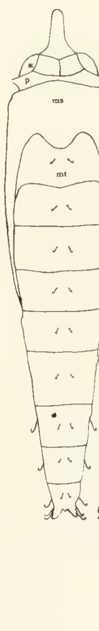

56

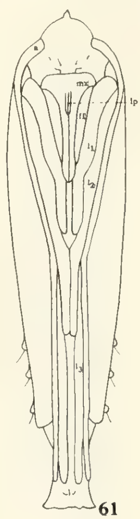

56a


59

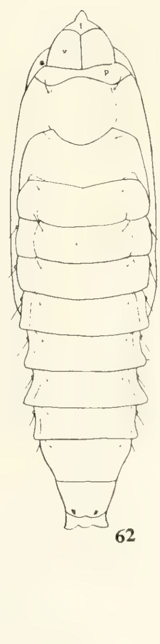

62b


57


58


61

62a


62

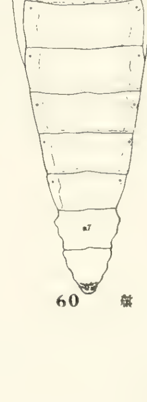

60

Plate XXIV

Fig. 64. Lithocolletis argentinotella, ventral view, female.
Fig. 65. Lithocolletis argentinotella, dorsal view, male.
Fig. 66a. Lithocolletis lucidicostella, dorsal view, cremaster.
Fig. 66b. Lithocolletis tiliacella, dorsal view, cremaster.
Fig. 67. Phyllocnistis insignis, ventral view, male.
Fig. 68. Eperminia pimpinella, ventral view, male.
Fig. 69. Galleria melonella, lateral view, male.
Fig. 70. Oxyptilus tenuidactylis, ventral view.
Fig. 71. Oxyptilus tenuidactylis, dorsal view.
Fig. 72. Atteva aurea, ventral view, male.
Fig. 73. Atteva aurea, dorsal view, male.
Fig. 74. Ephestia kuehniella, ventral view, female.
Fig. 75. Mineola indiginella, dorsal view.

PLATE XXIV

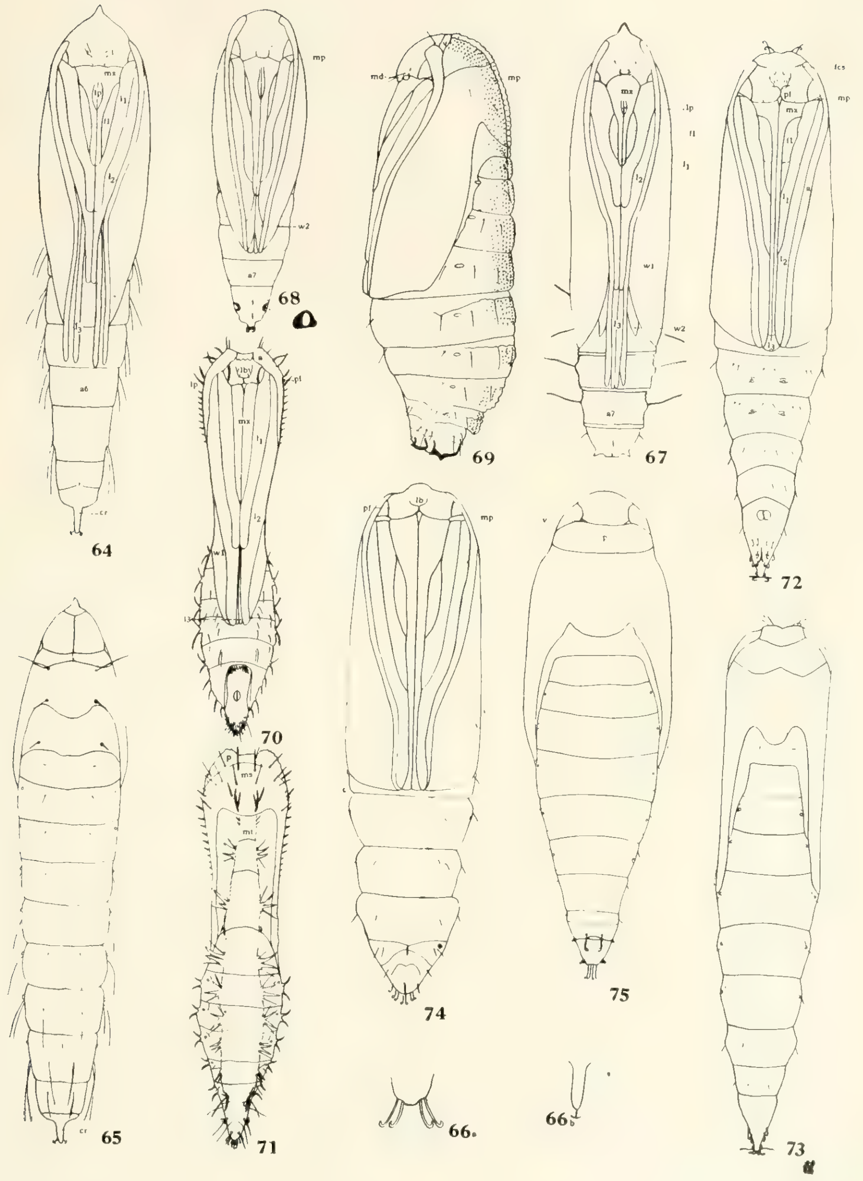


Plate XXV

Fig. 76. Pyrausta futilalis, ventral view, female.
Fig. 77. Epargyreus tityrus, lateral view.
Fig. 78. Calpodes ethlius, ventral view.
Fig. 79. Cyaniris ladon, ventral view.
Fig. 80. Oeneis semidea, ventral view.
Fig. 81. Euvanessa antiopa, lateral view, fifth abdominal segment.
Fig. 82. Zelleria celastrusella, ventral view, male.
Fig. 83. Yponomeuta malinellus, ventral view.
Fig. 84. Plutella maculipennis, dorsal view.
Fig. 85. Argyresthia freyella, ventral view, female.
Fig. 86. Argyresthia freyella, dorsal view, female.
Fig. 87. Coleophora malivorella, ventral view.
Fig. 88. Lophoptilus eloisella, ventral view, female.
Fig. 88a. Lophoptilus eloisella, lateral view, caudal end of abdomen.
Fig. 89. Scythris eboracensis, ventral view.

PLATE XXV

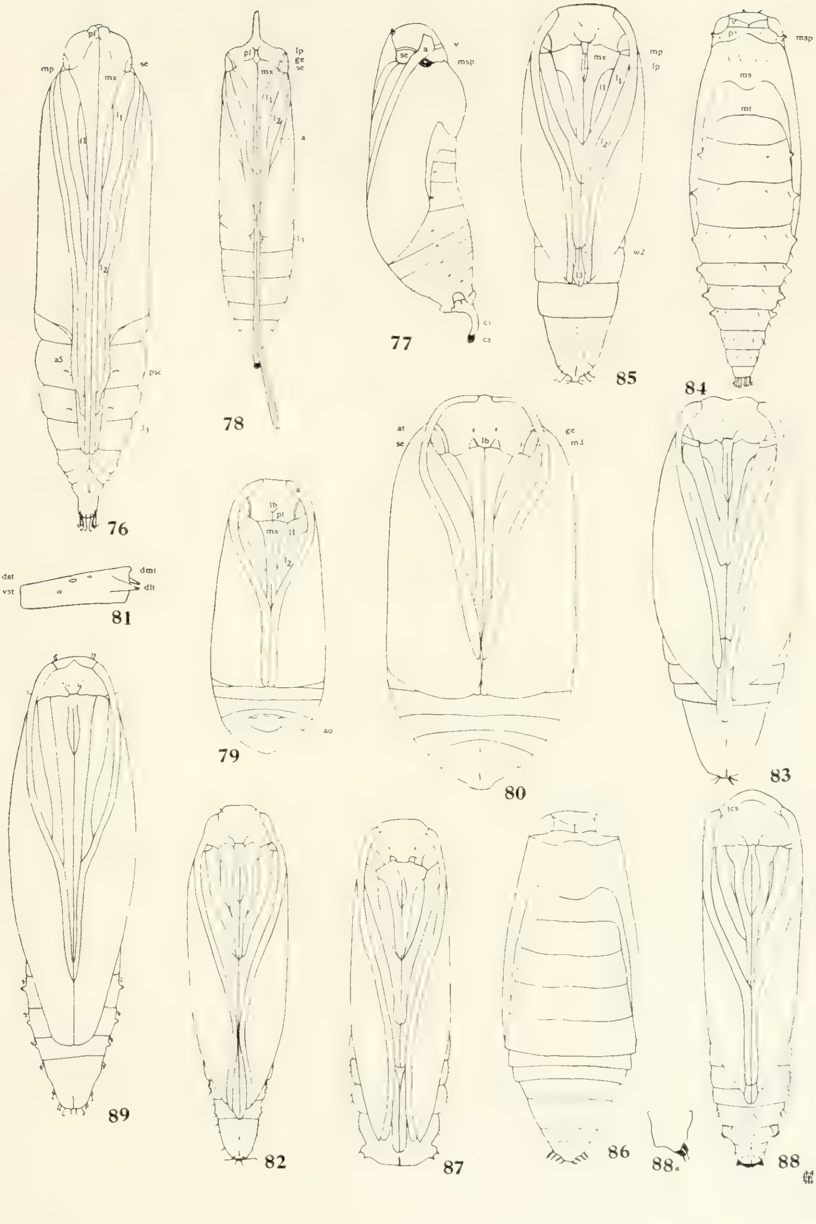

76
77
78
79
80
81
82
83
84
85
86
87
88
88a
89
pf
mp
se
mx
psc
lp
ge
msp
mt
ms
w2
at
lb
ao
dst
vst
dmt
dlt

Plate XXVI

Fig. 90. Gelechia serotinella, ventral view.
Fig. 91. Trichtotaphe flavocostella, dorsal view.
Fig. 92. Trichtotaphe flavocostella, ventral view.
Fig. 93. Evippe prunifoliella, ventral view.
Fig. 93a. Evippe prunifoliella, lateral view caudal end of abdomen.
Fig. 94. Ypsolophus citrifoliella, ventral view.
Fig. 95. Chrysopeleia ostryaeella, ventral view.
Fig. 96. Stenoma schlaegeri, ventral view.
Fig. 96a. Stenoma schlaegeri, dorsal and lateral views, fourth abdominal segment.
Fig. 96b. Stenoma schlaegeri, tips of large lateral setae.
Fig. 97. Psilocorsis quercicella, ventral view.
Fig. 98. Psilocorsis quercicella, lateral view.
Fig. 99. Cosmopteryx clandestinella, ventral view.
Fig. 100. Elachista praelineata, ventral view.

Plate XXVI

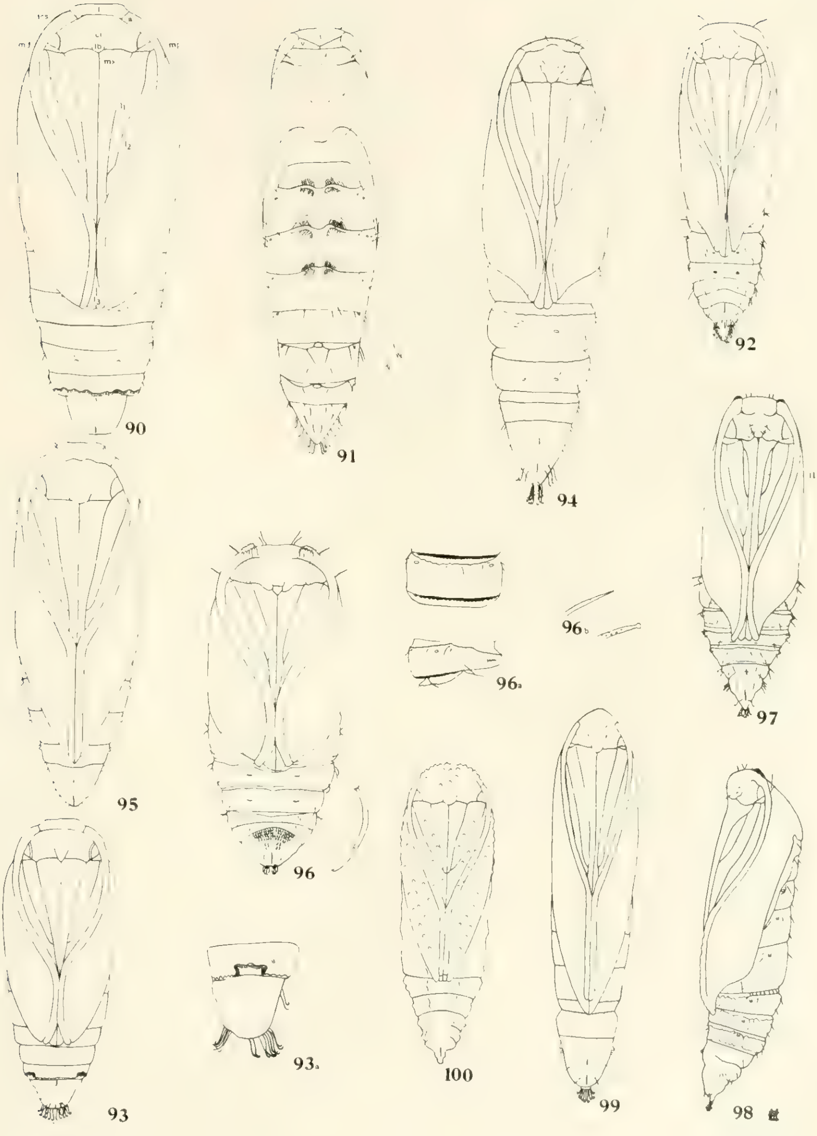
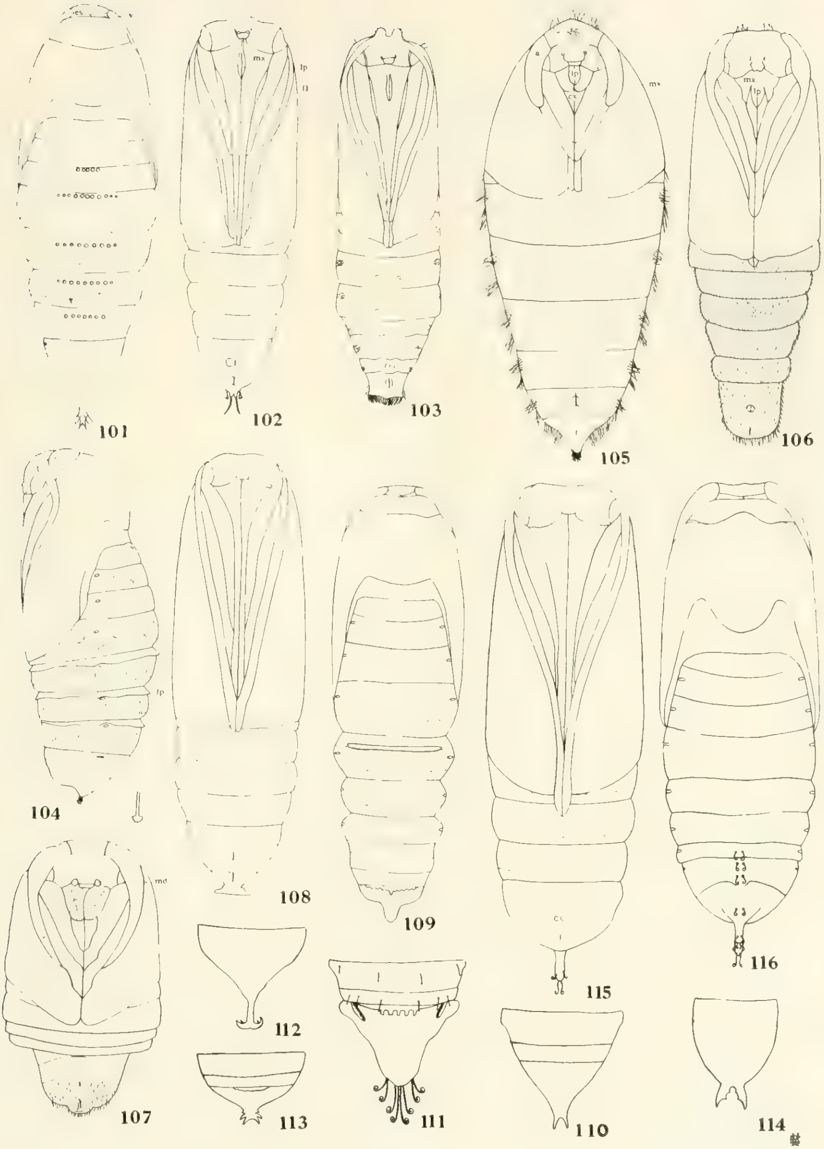


Plate XXVII

Fig. 101. Agrotis bicarnea, dorsal view.
Fig. 102. Cirphis unipuncta, ventral view.
Fig. 103. Eulonche oblinita, ventral view.
Fig. 104. Isia isabella, lateral view.
Fig. 105. Hemerocampa leucostigma, ventral view.
Fig. 106. Malacosoma disstria, ventral view.
Fig. 107. Bombyx mori, ventral view.
Fig. 108. Brephos infans, ventral view.
Fig. 109. Hydria undulata, dorsal view, cremastral setae not present.
Fig. 110. Cymatophora ribearia, dorsal view, caudal abdominal segments and cremaster.
Fig. 111. Tephroclystis absinthiata, dorsal view, caudal abdominal segments and cremaster.
Fig. 112. Melalopha inclusa, dorsal view, abdominal segments and cremaster.
Fig. 113. Datana angusii, dorsal view, caudal abdominal segments and cremaster.
Fig. 114. Schizura ipomoeae, dorsal view, caudal abdominal segments and cremaster.
Fig. 115. Phryganidia californica, ventral view.
Fig. 116. Phryganidia californica, dorsal view.

PLATE XXVII



BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH. D., LL. D.,
DIRECTOR

VOL. XII. MARCH, 1917 ARTICLE III.

A PRELIMINARY CLASSIFICATION OF DIPTERA, EXCLUSIVE OF PUPIPARA, BASED UPON LARVAL AND PUPAL CHARACTERS, WITH KEYS TO IMAGINES IN CERTAIN FAMILIES. PART I.

BY

JOHN R. MALLOCH

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH. D., LL. D.,
DIRECTOR

VOL. XII. MARCH, 1917 ARTICLE III.

A PRELIMINARY CLASSIFICATION OF DIPTERA, EXCLUSIVE OF PUPIPARA, BASED UPON LARVAL AND PUPAL CHARACTERS, WITH KEYS TO IMAGINES IN CERTAIN FAMILIES. PART I.

BY

JOHN R. MALLOCH

CONTENTS

Article III.—*A Preliminary Classification of Diptera, exclusive of Pupipara, based upon Larval and Pupal Characters, with Keys to Imagines in certain Families. Part I.* By J. R. Malloch.

Introduction

Economic and taxonomic entomologists have long felt the need of a synoptic treatise on the immature stages of Diptera. Owing to the added impetus given to the study of this order by the comparatively recent discovery of the economic importance of certain members of the Diptera, the lack of available literature in English dealing with the larvae and pupae has been considerably emphasized. It is not the intention of the writer to attempt a definition of the larval and pupal characters that may be depended upon invariably for the separation of all the families of the order; a simple presentation of the main features involved in the differentiation of the families, genera, and species available to him is all that is attempted. It may be that these characters will in the main, with necessary modifications, prove of fundamental importance; but even if later they must needs be relegated to the category of things that have been they will at least have served the purpose for which they were intended—the identification of a number of important economic groups—and also constitute stepping-stones to the firmer ground that can be reached only by a more extended knowledge of the larvae and pupae, and by means of patient and intelligent comparative examination of a larger amount of material than is now at my command.

I have been requested by several of my entomological colleagues to undertake the task of presenting analytical keys to the immature stages of Diptera, but for lack of material that would add to the information already published I have hitherto refrained from doing so. I have been steadily acquiring material, however, for over two years, which, taken in conjunction with material previously in the collection here and that kindly loaned me, probably includes more examples of immature stages of Diptera as a basis for classification than have been brought together elsewhere in the United States. It is, moreover, my opinion that when any entomologist has a considerable amount of additional information upon any phase of a subject it is

incumbent upon him, in the interest of his fellow workers, to publish not only his new data, be they new species or life histories, but incidentally to link up with his data such facts already published as have a direct bearing upon the subject in hand. It undoubtedly takes valuable time to make a comparative description of a new species, and where several species in a genus require to be described it necessarily means considerable work to the describer to make a synoptic key to the whole genus as well as to give a description of each of the new species. But when one considers that the time so spent is infinitesimal as compared with that saved to subsequent workers who would otherwise have to puzzle over descriptions in order to discover the differentiating characters, it is evident that synopses and comparative descriptions are not only useful but should be regarded as indispensable in scientific work.

It is not with the intention of assisting the narrow specialist that this paper is written; the purpose is to enable the observant student of nature and the economic entomologist to recognize those forms that often come to their notice and thus obviate the frequent delays and discouragements in obtaining information through other channels. If this object is attained, even in a small measure, science will have gained some advantage and the author will be satisfied.

An effort has been made in the general discussions, and particularly in connection with life histories, to avoid the use of pedantic terminology, as the writer is of the opinion that except in formal descriptions clarity of expression can be attained and conciseness compassed by the use of language that is understood by the non-entomological reader, much of the terminology and phraseology incessantly cropping out in entomological publications being due either to the training or the personal whim of the writers.

This paper deals primarily with Illinois species, most of the material used having been collected in the state by the various members of the staff of the State Entomologist's Office or that of the State Laboratory of Natural History. In a few cases, however, I have used extralimital material belonging to our collections, and have also borrowed examples of either larvae or of pupae, or of both, which were not obtained in Illinois, in order to ascertain by an examination of the specimens information not included in previously published descriptions that would enable me to complete, as far as possible, data upon certain genera or species.

The classification adopted is essentially that used by Brauer in 1883*; but in detail I have not accepted his arrangement, nor have I

*Denkschr. k. Akad. Wissensch., Wien, math.-naturw. Cl., 1883, pp. 1–100.

used his anatomical nomenclature, for, as has already been pointed out by Lundbeck in his "Diptera Danica", Brauer has erred in this paper in the interpretation of different parts of both larvae and pupae. These misinterpretations are not emphasized herein, as the present writer believes that in undertaking original work such errors are likely to occur, and that in viewing the results of the efforts of authors we ought to adopt a perspective that permits a correct appreciation of the difficulties under which the work was done. By this means we shall arrive at an estimate of the infinitesimal nature of existing blemishes in comparison with the immense advantages afforded to succeeding workers by a perusal of the author's published results. The present paper is presented without any foolish assumption of infallibility, and, as already stated, with a view to adding to the knowledge we already possess of the early stages of North American Diptera.

In order to keep the size of the paper within as small a compass as possible, descriptions of species published by the writer in previous papers are not reproduced, but citations are uniformly given to facilitate reference to them.

ACKNOWLEDGMENTS

I have to acknowledge the assistance rendered me in this study by the loan or gift of material as follows: from Dr. E. P. Felt, State Entomologist of New York; from W. L. McAtee, of the U. S. Bureau of Biological Survey; from J. J. Davis and J. A. Hyslop, of the U. S. Bureau of Entomology; from C. W. Johnson, of the Boston Society of Natural History; and from Dr. R. D. Glasgow, of the University of Illinois. In 1890-91 Dr. S. A. Forbes obtained a large amount of material from the streams and lakes in Yellowstone National Park, some of which represents genera and species of Diptera not in our collections from Illinois, and these have been used as a basis for contributory descriptions. Most of the material from the Illinois River which I have studied in this connection was collected by Mr. C. A. Hart, and some of it was used by him in preparing his paper on the Entomology of the Illinois River*. Several of the species discussed or described were obtained by W. P. Flint and D. K. McMillan in the course of their field work for the State Entomologist's office.

HABITS AND HABITATS OF SPECIES

Under family headings and very frequently in the discussion of genera I have given notes upon the habits of larvae and imagines,

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI. (1895)

while in the case of species that I have reared the notes furnish data upon the habitat. This makes unnecessary preliminary details on these points. In fact the Diptera have such a variety of habits in the larval and imaginal stages, and are so generally distributed, that one might be pardoned if he were to dismiss the subject with the laconic remark, "omnivorous and omnipresent".

METHODS OF COLLECTION AND PRESERVATION

It is necessary, in my opinion, in papers of this nature to give some general directions regarding methods of collecting and, as a part of collecting, rearing species.

For the ordinary collecting of forms that frequent manure, decaying wood, fungi, and mud or comparatively dry earth, as well as phytophagous species, the best temporary receptacle is a small round tin box about an inch and a half in diameter and three fourths of an inch deep. Dealers in entomological supplies have these for sale, and they may be obtained with a paper-covered lid, upon the surface of which necessary data may be written. Many species may be reared to maturity in these boxes, the principal objection to this course being that it is not possible to learn whether the flies have emerged without opening the box, and frequently the specimen escapes upon the removal of the lid.

I have had very satisfactory results with rearing-cages consisting of Petri dishes, the upper dish fitting over the lower when inverted. These cages, especially in the spring, proved all that were required to produce imagines from the larvae of Empididae, Xylophagidae, Syrphidae, and many other families.

Aquatic species may be put in Mason fruit-jars or in small bottles, a convenient size of the latter being two-ounce. If not too tightly corked, specimens may be kept in such receptacles over night, but I find it best to use a cotton stopper instead of a cork unless while carrying the material in from the field. Many species, in fact most of the smaller forms, may be successfully reared in the two-ounce bottles, but I prefer to remove them during the pupal stage, or just before they transform to that stage, to a two-dram vial containing a little water and fitted with a cotton stopper. If transferred before transforming to the pupa the larval skin may be more easily found than in the larger bottle.

A mistake frequently made by entomologists in preserving larvae is to put the live specimens into 85% alcohol. This course almost invariably results in a shrinking of the skin and consequently seriously

impairs the value of the specimens. In order to procure the best results in the case of soft-bodied specimens it is especially necessary that the examples be placed at first in water, which should gradually be brought to the boiling point, or near it, and then set to cool. If the water is allowed to boil violently it often results in a distortion or over-expansion of the specimens. Upon removal from the cool water place the specimens in 25% alcohol to remain six or eight hours; next transfer them to 50% strength, in which they should remain twenty-four hours,—after which treatment the larvae may safely be transferred to 85% alcohol, in which they should be kept.

Pupal exuvia that have the integument chitinized may be preserved dry, but even such forms must be placed in alcohol if the imago has not emerged, as they shrink very much when preserved dry.

I have succeeded in obtaining presentable specimens from completely dried-out larval and pupal exuvia by boiling them in water. A larva or a pupa after drying out is rarely restored to its original form except by much patient work; but exuvia, even months after they have dried out, invariably recover their form when boiled.

The head parts are generally easily traceable in larval exuvia, but in preserved larvae, especially of Brachycera and Cyclorrhapha, in which the head is retracted, dissection must be resorted to in order to get at the internal structures. I have had some success in ascertaining these details when I did not wish to cut up the specimen, by boiling it in 10% potash; but this is a tedious operation, especially if the specimen is a large one, and I prefer to expedite matters by cutting off the anterior two thoracic segments—caudad of which the cephalic skeleton does not extend—which may readily be cleared so that dissection is possible in a few minutes.

The larger species have such heavily chitinized opaque heads that they are not good objects for slide mounts, but the smaller ones should invariably be mounted in Canada balsam. It is always necessary that some system of cross-reference be used for slide, vial, and imago in order to facilitate reference.

More detailed information upon methods of mounting specimens is given in my article on the Chironomidae of Illinois.*

ECONOMIC IMPORTANCE OF THE ORDER

No other order of insects equals the Diptera in diversity of habits in larval and imaginal stages. Many of the families are largely beneficial, but unfortunately the good done by them is counterbalanced by

*Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. VI. (1915)

the injury inflicted by others. The essentially phytophagous families, that is those families of which the great majority of the species feed upon plants, are very greatly outnumbered by those that are scavengers or predaceous or parasitic. If we exclude those that are fungivorous, only four families remain that can be classed as preponderatingly phytophagous—Cecidomyiidae, Trypetidae, Agromyzidae, and Chloropidae; a few species in these families are predaceous. It must be borne in mind that a phytophagous species is not necessarily injurious from the economic standpoint, as many species feed upon and keep in check noxious plants and may therefore be regarded as beneficial.

It is but a step from the phytophagous to the scavenging habit, and in Drosophilidae we find species that may feed upon Cruciferae, mining the leaves, or in sap exuding from trees and in vegetable refuse. Few other scavenging Diptera feed upon living plants, the only additional exception known to me being those that are fungivorous. There are eight families that may be considered as essentially fungivorous—Macroceridae, Bolitophilidae, Platyuridae, Mycetophilidae, Sciaridae, Platypezidae, Phoridae, and Drosophilidae. Many of the Sciaridae occur in decaying vegetation, while the habits of Phoridae are remarkably diverse, some being true entoparasites.

The scavengers belong to more than a score of families. In Muscidae all the species scavenge; but in some other families, Anthomyiidae, for example, we find phytophagous and inquiline species, though these are greatly in the minority and the family is essentially one of scavengers. The Sarcophagidae include some species that are true entoparasites, but the great majority are feeders upon decaying animal and vegetable matter. The scavengers are in the great majority of cases really beneficial, transforming dead animal and vegetable matter into such forms as can be utilized as food by growing plants. In reducing the bulk of putrefying substances, which, absorbed by the growing larvae, are transformed into the bodies of the resultant imagines, they remove what is noxious to man. It is chiefly when scavengers such as the common house-fly contaminate our food by contact, after feeding on foul substances which are impregnated with disease germs, that there is real danger from these insects. Rarely the screw-worm fly and some of the flesh-flies deposit their eggs or larvae in wounds, either on man or on animals, and in this manner produce serious ulcerations, and the larva of the former has been known to cause the death of persons by penetrating the brain, which it entered by way of the nasal passages. The flesh-flies and some other groups sometimes cause myiasis in man, the larvae finding their way into

the stomach with food in which the flies have deposited their eggs or larvae and which has not been prepared for consumption by judicious cooking, or carefully examined so as to exclude infested portions.

We may class as true parasites nine families, some of which, as Tachinidae (*sens. lat.*), Dexiidae, and Pipunculidae, are highly beneficial, and others, as Gastrophilidae, Hippoboscidae, and Oestridae, are distinctly injurious. The parasites of this order destroy many injurious species of insects, and, next to the parasitic Hymenoptera, constitute the most important check upon their increase.

Another group of highly beneficial species is that containing the predaceous forms. Two of the families which are to some extent beneficial in the larval stage—Tabanidae, and Culicidae in part—are injurious as imagines, turning their attention from insect larvae, on which they chiefly prey in the early stage, and giving it largely to mammals, including man. This radical change of habit is, however, exceptional, as other predaceous families in this and other orders feed upon insects in both the larval and imaginal stages. Many Syrphidae are aphidophagous as larvae, the greater portion of the species being scavengers, while the imagines are flower-frequenters.

The aquatic families, with the exception of the Sciomyzidae and Ephydridae, which are in large part aquatic, belong to the Orthorrhapha. With the exception of the Mycetophiloidea, which contains five families, the Oligoneura, which contains the Cecidomyiidae, and the families Bibionidae and Scatopsidae, all the families in the division Nematocera are aquatic either wholly or in large part. The aquatic species in the division Brachycera are contained in five families—Leptidae, Stratiomyiidae, Tabanidae, Empididae, and Dolichopodidae. As already indicated in the foregoing general discussion, the larvae of some of these families are predaceous and may justly be considered beneficial; the others feed upon algae and decaying vegetable matter, and while their presence in water that is intended for drinking purposes is undesirable it is not necessarily harmful unless the vessel containing them is small and they are numerous enough to foul the water, either with excreta or exuvia. With the exception of some Chironomidae and Culicidae there are few species that frequent reservoirs or cisterns, most of them preferring lakes, ponds, or streams.

My information regarding the habits of the order in general leads me to the conclusion that as a whole their beneficial and injurious activities practically offset each other. The fact that there are injurious species which cause great recognized damage, such as the malarial and other disease-bearing mosquitoes and the Hessian fly, very largely outweighs in the mind of the uninformed the benefits—

few of which are apparent except to a student of the Diptera—that are directly or indirectly due to the presence of other forms. With advance in a knowledge of the biology of the insects of this order will come a realization that their injurious and beneficial effects are practically balanced.

ARRANGEMENT OF FAMILIES

In agreement with the method generally used by systematists in zoological work, the arrangement of the Diptera is in accordance with the generally accepted theory of evolutionary development, and the families are thus arranged as nearly as possible in their natural sequence from lowest to highest, using as criteria the rather limited data furnished by available life histories, and by a study of imaginal characters; but in endeavoring to trace affinities the reader must bear in mind that the families included are but the tips of the evolved branches, and not the entire genealogical tree. The hypothetical primitive dipterous larva is assumed to have had a complete head with horizontally moving mandibles, the head enclosing the first ganglion; three thoracic segments, the prothoracic with a pair of spiracles; and ten abdominal segments, the anterior seven, or more, with lateral abdominal spiracles. No larva of this order has yet been discovered which possesses true thoracic legs, but there are many species that have pseudopods or sensory organs upon some of the thoracic segments. This anatomical feature is not accounted as pertaining to a consideration of the phylogeny of the group, as pseudopods are generally regarded as of secondary importance, being developed, partially developed, or absent, in species within the same family.

The head is the best single unit available under all circumstances for the purposes of classification, as it is wholly or in large part chitinized and its component parts are accessible for examination either as a composite mass or after dissection, even in alcoholic material, whereas the nerve ganglia and even the tracheal system of alcoholic material are often indistinguishable, and in the case of exuvia entirely lost. The modifications exhibited in the head of the different families are remarkable, and though there are rather abrupt breaks in the chain of ascent as we pass from the Nematocera, with their opposed mandibles and complete or almost complete head-capsule, to the Brachycera, with their vertical subparallel mandibles and much reduced head-capsule, and, again, from the higher forms of this group to the Cyclorrhapha, and particularly to the Muscidae, one can trace with considerable probability the line of evolution up to the most highly

specialized forms of the present day. In this paper a large series of figures of heads of larvae belonging to all the principal sections is given in order to exemplify the evolutionary phases and, incidentally, to permit the student to judge as to the correctness of the classification by a comparison of the available data thus presented in the most readily comprehensible manner. An unillustrated discussion of anatomical details affords no check on possible misstatement or misinterpretation by an author or on misconstruction of his words by the student, and to prevent error from one source or another such discussions should be accompanied by figures.

Brauer divided the Orthorrhapha into three tribes, Eucephala, Polyneura, and Oligoneura, using the structure of the head as his primary character in separating the groups, Eucephala having the head entire, the others having the head-capsule incomplete posteriorly. Oligoneura has in addition to an incomplete head-capsule vestigial mandibles, a character which separates the tribe from the other two. Brauer's classification has been generally accepted, though several writers have pointed out what they consider to be errors in grouping that result from the application of his rules, and Sharp has gone so far as to suggest that his system has been influenced by his use of dichotomic tables*.

Recently a suggestion has been made that as the group Nematocera is apparently an unnatural one, containing, as it does, some widely dissimilar families which fall together according to Brauer's classification, we should attach primary importance, not to the structure of the head but to the respiratory system†. Here, again, an arbitrary attempt has been made to divide the group Nematocera into two tribes, Oligoneura and Polyneura, using the respiratory system as a basis for the division. In some respects the suggestion is an improvement upon Brauer's system of classification, but even so, the composition of both groups shows some confusion which to my mind proves that the respiratory system is not an ideal character on which to base tribes. In fact the only point clearly shown is that some species of all of the families of Oligoneura, rarely, all species of some of them, are peripneustic and hence assumably primitive structurally, while all species, so far as is known, in Polyneura are amphipneustic, metapneustic, or apneustic. That there are both metapneustic and apneustic forms in Oligoneura of this latter classification, and that several have the lateral abdominal spiracles functionless and may

*Verrall's "British Flies", Vol. 5, p. 31. (1909)

†Knab, in Ann. Ent. Soc. Amer., Vol. 7, 1915, p. 93.

therefore be considered as amphipneustic does not seem to have much weight with those who follow this dichotomic arrangement. Peripneustic larvae occur in Dolichopodidae and vestigial spiracles are present in some Strayiomyiidae—facts which point, not to the more primitive nature of the species possessing these organs but to the persistence of the latter because of their utility in the larval habitat.

There must be a further division of the tribes in Diptera, but until we have data upon a larger number of species in the order any proposed subdivision, including that of the present paper, must necessarily be merely tentative. I give a figure of a hypothetical genealogical tree of Orthorrhapha which illustrates my opinion of the relations of the various families (Fig. 1). There are defects in the scheme that will probably be obvious to many, and it remains for some future worker to improve on the suggestion here given. The sequence of families in this paper is according to the author's ideas, differing somewhat from that in Williston's "Manual", but subject to amendment upon discovery of new data.

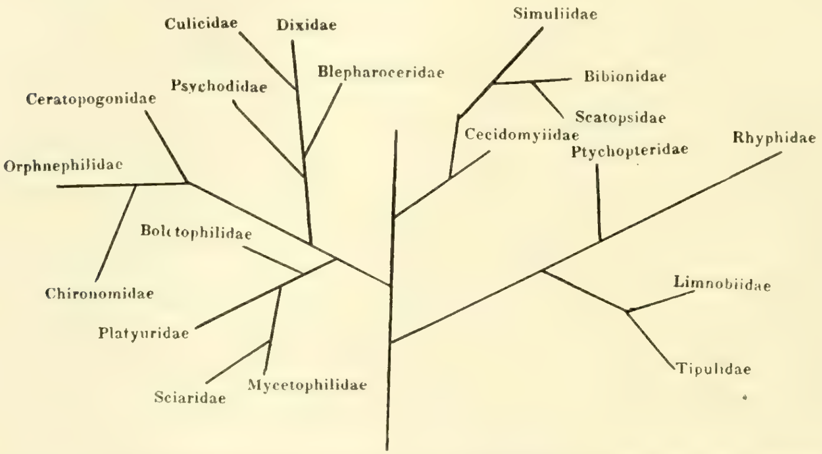


FIG. 1. Hypothetical genealogical tree of Nematocera, illustrating the grouping in this paper.

The nervous system as a means of identification may be eliminated because of its limited applicability—in preserved material—but we may with little reserve accept as one of the primary indices to affinities the nature of the respiratory system. Insects normally breathe by means of thoracic and abdominal spiracles, and these are found in the adults and in a great majority of the pupae of the Diptera. It is the exception, however, to find them in the larvae, and as a means of

identifying those of many of the lower families the absence or presence of the lateral abdominal spiracles is of considerable importance. It is not to be expected that a rule will be discovered as to the absence or presence of these spiracles which will be of invariable applicability to all the families—as at present constituted—in the Nematocera, because we find, from data already in hand, that there appear to be several exceptional genera within the group, and also because peripneustic larvae occur in much higher families. Taken in conjunction with the structure of the head, however, it is quite possible that the absence or presence of the lateral abdominal spiracles may prove to point to the tracheal system as of primary importance in classification. It must be borne in mind that many families as at present constituted include genera whose larvae have widely different habits, both terrestrial and aquatic forms occurring at times in closely allied genera and, rarely, within the same genera. In this connection it seems pertinent to indicate that our system of arrangement is based primarily upon the characters possessed by the imagines, but investigators may, without compunction, remedy errors in the system which, by an examination of the immature stages, are shown to exist.

One of the principal characters cited by Brauer for the separation of the Orthorrhapha from the Cyclorrhapha is the nature of the splitting of the larval skin when the pupa or adult emerges. In the former the skin splits on the dorsum in the shape of a T or +; whereas in the latter—in which the skin hardens in the last stage to form an enclosing puparium—the splitting is usually transversely across the entire dorsum and venter, so that the anterior portion of the puparium comes off cap-like; or there may be also lateral splits that cause the upper and lower halves of the anterior portion to separate. The lines of dehiscence in Cyclorrhapha puparia are not accidental, but are clearly provided for by weak parts in the membrane. The emergence of the imago in Orthorrhapha is assisted by a slight swelling in the thoracic region, and by movements of the developing wings and hardening legs; in Cyclorrhapha the operation is facilitated by the dilation, with air, of a bladder-like sac immediately over the antennae, which, when swollen, forces apart the anterior extremity of the puparium along the lines indicated by the thinner membrane. After emergence the ptilinum, as the bladder-like structure is called, is retracted within an aperture above the antennae and forms a pouch-like cavity. The existence or absence of this peculiar structure in the imagines constitutes the primary character for the separation of the two suborders—Orthorrhapha being without and Cyclorrhapha with a ptilinum, its presence being indicated by what is called the frontal triangle, im-

mediately above the antennae. The families Lonchopteridae, Pipunculidae, and Platypezidae have a very poorly developed ptilinum or it is undeveloped, but other characters appear to align them with Cyclorrhapha.

In the Orthorrhapha, the imagines of the Nematocera have the antennae usually much elongated and consisting of 7 or more distinct joints; the Brachycera have the antennae consisting of 3 joints, the third being either simple or composed of a number of closely fused ring-like joints having the appearance of an elongated single joint with more or less distinct subdivisions, and there is also, sometimes, a terminal or dorsal arista or style. In the Cyclorrhapha the antenna consists of 3 joints and a terminal or dorsal arista, the second joint in some families being small and entirely or almost entirely enclosed within the very large third, so that the antenna appears to consist of only 2 joints. The wing veins offer a good character for the differentiation of the families throughout the order, and being readily accessible have been made much use of by taxonomists. The lower forms have a much larger number of longitudinal veins than do the higher, and this seems to point to a coincident reduction of antennal segmentation and wing venation in the evolution of the families of the order.

An interesting piece of histological work might be undertaken in connection with the development of the members of the Muscidae and allied families, particularly in the observation of the developmental processes of the head-parts, which are so much reduced in the larvae of these forms.

I present in this paper a key to the imagines of the families of North American Diptera based upon the most recent data available. I have made use of many characters that are not in existing text-books, and in doing so I have simply attempted to put into writing data that many specialists merely carry in their minds. The characters used by Schiner and others for the separation of European families and genera are as a general rule applicable to North American Diptera, but there are many intermediate forms here that do not occur in Europe, and as the keys in use here have largely been copied or adapted from those in use in Europe considerable discretion is required in locating members of many families by these keys. The described dipterous fauna of this country is growing beyond the possibility of competent handling by one individual, and frequently men who are authorities on certain groups are unable to do more than make a guess at the family status of a particular species. I make this explanation in the hope that students will realize certain facts: that the beginner in the study is facing a stiff task in this order; that the knowledge we possess concerning

the order is comparatively meager; and that I realize the possibilities of error that beset me in the present attempt.

SCOPE OF WORK

In order to keep the size of this paper within a reasonable compass I have given generic keys to imagines of those families only that are not correctly dealt with in Williston's "Manual of North American Diptera".

I have covered the larval and pupal stages of all the groups available to me, depending but rarely upon printed descriptions for differentiating characters. In the Orthorrhapha I have succeeded in obtaining larvae or pupae, or both, of all the families except Macroceridae, Orphnephilidae, Nemestrinidae, and Apioceridae. The Cyclorrhapha are not so fully represented, but I have a large quantity of material on hand which will serve as a basis for an extensive paper on this group, and this will be published as Part II of the present article.

A bibliography of general papers on Diptera will be given at the conclusion of Part II, and papers upon single families will be listed in connection with the text dealing with such families.

CHARACTERS OF THE LARVAE

Suborder ORTHORRHAPHA

Division NEMATOCERA

Broadly speaking, the dipterous larvae of Brauer's eucephalous group of the Nematocera may be distinguished from those of other Diptera and also from other orders, by the following characters.

Head with opposed, usually toothed, mandibles, often, in the aquatic or semiaquatic forms, with conspicuous brushes on their external surfaces; variously constructed antennae which may be barely distinguishable elevations (Mycetophilidae, Sciaridae) or elongated, and consisting of from 1 to 6 joints and occasionally retractile within the head (Tanypinae); well-developed maxillae with 1- or 2-jointed palpi; no well-developed labial palpi; a more or less chitinized labial plate, or submentum, which is frequently dentate upon its anterior margin; eyes, when present, indicated by a single or double pigmented area on each side. True legs never present; prothoracic segment occasionally with a pair of pseudopods which may be entirely or partly fused (Chironomidae, Simuliidae); anal segment in some cases with a pair of more or less elongated pseudopods which are sometimes armed with curved retractile claws in 2 or more concentric series;

abdominal, and occasionally also thoracic, segments sometimes with locomotor spinules in transverse series on portions of their ventral surface (Mycetophilidae, part) or with pseudopod-like elevations or fusiform transverse locomotor areas; respiratory system consisting, in its highest development, of 1 pair of prothoracic, 7 pairs of abdominal, and 1 pair of anal spiracles, the abdominal pairs not functional in some cases (Simuliidae, and Bibionidae and Scatopsidae ?), while in other families they are absent entirely, respiration being carried on either by means of the anal spiracles, or by these and the prothoracic pair, or by means of blood-gills on the anal segment which are sometimes retractile (Simuliidae, Ceratopogonidae) or permanently exserted (*Chironomus*, part).

The acephalous larvae differ very markedly from those of the other group in the reduction of the head-capsule. In Cecidomyiidae the mandibles are vestigial or absent and the posterior portion of the head is poorly defined and membranous, but the larvae may be distinguished by the presence of 13 segments, in addition to the head; by the lateral abdominal spiracles; and, usually, in the last instar, by the presence, on the ventral surface of the first and second thoracic segments, of a chitinized plate, generally referred to as the "breast-bone", which is differently shaped in different species and is used by the mature larvae as a means of propulsion in making their leaps after leaving their cells for pupation—in cases where this change is made in the ground. In other larvae of this group there are at most but 12 distinct segments in addition to the head.

The reduction of the head-capsule in Tipulidae and Limnobiidae is in the form of a breaking up of the fusion of the component parts posteriorly, the caudal portion of the head thus having the appearance of several slightly diverging rods, the membrane of the prothorax being attached to the head just anterior to the point of divergence. These larvae may be distinguished from those of the higher families of the Brachycera by their opposed, instead of parallel, mandibles. Respiration is carried on by means of prothoracic and anal spiracles—the latter supplemented in the aquatic forms by retractile blood-gills on the ventral surface of the last segment—or in some genera by the anal spiracles only.

Division Brachycera

The larvae of Brachycera are usually readily distinguished by the large maxillae, with their normally conspicuous palpi, between which are the slender labrum and the vertically moving, knife- or sickle-shaped mandibles on each side of it. The antennae are sometimes conspicuously elevated but occasionally very short, and the eyes

are often readily distinguishable. The head is usually almost fully retractile within the thorax, being permanently exserted in Xylophagidae, Coenomyiidae, and Stratiomyiidae. Respiration in this group is normally carried on by means of prothoracic and posterior spiracles, the latter being situated upon the ultimate (Stratiomyiidae, Leptidae, etc.), penultimate (Asilidae, Mydaidae, Bombyliidae), or antepenultimate (Therevidae, Scenopinidae) segments. Some species of peripneustic Dolichopodidae are an exception to this rule. Many species of Brachycera have on their ventral surface locomotor organs, which may consist of mere transverse irregular swellings (Asilidae, in part, Mydaidae, Bombyliidae, etc.), paired pseudopods (Leptidae, part), or transverse series of spinules (Xylophagidae). Many of the families have conspicuous bristles on the body surface, especially on the ventral surface of the thoracic segments and the dorsal and apical surfaces of the anal segment (Asilidae, Mydaidae), or on all of the thoracic and abdominal segments (Xylophagidae, Stratiomyiidae).

The normal number of segments in this group is 12, exclusive of the head; but in several families—Tabanidae, Stratiomyiidae, Leptidae—only 11 are distinguishable. Except in the Stratiomyiidae the pupa is free, that is to say, not enclosed in the indurated larval skin. Rarely the pupa is enclosed in a loose cocoon (*Medeterus*) or in a very compact one (*Drapetis*).

Suborder CYCLORRHAPHA

Division Acroptera

This group includes but one family, Lonchopteridae. The systematic position of the group has long been in doubt, but the most recent and comprehensive work upon all stages of the species clearly points to their much closer affinity with the Cyclorrhapha than with the Orthorrhapha. The larvae are distinguishable from those of other Diptera by the fact that they have but 9 well-defined segments in addition to the head.

A full discussion of the characters of this group appears under the family heading on a subsequent page.

Division Aschiza

This group consists of Syrphidae, Pipunculidae, Platypezidae, and Phoridae, according to Brauer. I have before me larvae and puparia of all but Pipunculidae. The cephalopharyngeal skeleton is better developed in this group than in Schizophora, but it is less perfect than in the most specialized orthorrhaphid larva. In the aphi-

dophagous Syrphidae there are upper and lower chitinized mouth-hooks, which consist of two convergent lateral pieces with a V-shaped anterior extremity and correspond to the pair that are present in Schizophora; but in addition to these there are two to four pairs of small chitinized points or hooks which work horizontally and serve the purpose of grasping prey. The mouth-hooks in Schizophora are not V-shaped and the lower one is absent. These chitinized pieces are less readily distinguishable in the aquatic Syrphidae but are present in modified form, while the mouth-margin is specialized. The antennae in all species of the latter family are distinct, usually consisting of a single joint, rarely two, with a pair of short apical processes. The body consists of 12 segments, but the segmentation is indistinct because of the presence of numerous transverse wrinkles or folds in the integument; the surface of the body in most species bears regularly arranged bristles, which are occasionally upon slight elevations and serve to distinguish the different segments. Pseudopod-like structures are often present on ventral abdominal segments, their apices armed with short bristly hairs. Respiration is by means of prothoracic and anal spiracles, the former occasionally doubtfully functional or apparently absent, the latter protruding occasionally in a tube-like appendage.

The larvae of Platypezidae resemble some of the Syrphidae rather closely, and bear a striking resemblance to the anthomyiid subfamily Fanniinae in having fringed projecting processes on the body segments. The more elaborate mouth-parts readily separate them from all Anthomyiidae, and also, in my opinion, associate them more closely with Syrphidae than with Phoridae, though Brauer places them with the latter in the tribe Hypocera.

The Phoridae are much simpler in general form than most Syrphidae and all described Platypezidae, possessing, in as far as they are known, no prominent body appendages. The mouth parts are similar to those of the other families of the group in having anteriorly fused mouth-hooks. The larvae are amphipneustic—possessing prothoracic and anal spiracles.

The transformation to the pupa takes place within the last larval skin.

Division Schizophora

The larvae of this group, which contains a great majority of the members of this suborder, are readily distinguished from those of any other order by the remarkable reduction of the head, which, when seen laterally, consists of a V- or U-shaped chitinized posterior plate, which has two posteriorly divergent dorsal rods, and, attached to the

anterior extremity of this plate, another, smaller plate, which is anteriorly curved downward and consists of two—rarely one—hooks or mandibles which are either simple or toothed and operate vertically, scraping or abrading the surface of the larval pabulum so that the food is drawn downward and inward to the mouth cavity. These mouth-hooks, and the entire cephalopharyngeal skeleton, are retracted when the larva is at rest. The respiratory system consists of prothoracic and anal spiracles which are connected by means of two large main tracheae, the latter being normally connected by means of a slender transverse trachea just behind the prothoracic spiracle, and each sending out upon each segment a stout downwardly and slightly forwardly directed stout trachea with numerous branches, and, in addition, a smaller trachea, which is an offshoot from the inner surface and is directed almost straight cephalad. The structure of the spiracles is of great value as a character in the classification of this group. The anterior spiracles are often questionably functional in the aquatic forms, and are sometimes almost or entirely absent in parasitic species, the connection with the air being maintained entirely by means of the posterior pair. Means of locomotion in this group consist of spines on various portions of the thoracic and abdominal segments, with, occasionally, poorly developed pseudopods on the abdominal segments, particularly on the apical segment. Rarely there are elaborate appendages upon the thoracic and abdominal segments (Fanniinae), but more frequently the surface of the segments is bare except for the locomotor organs. The larvae transform to the pupal stage within the indurated last larval skin, which is then referred to as the puparium. In this stage characters are frequently developed that are of value in classification; these are dealt with in the section upon characters of the pupae.

Characters of the Pupae

Suborder ORTHORRAPHA

Division Nematocera

The aquatic members of this group may in the main be separated from those of the Brachycera by their stalked prothoracic respiratory organs, which are occasionally numerously filamented apically. The few species that are recorded as having these organs sessile may be distinguished from brachycerous pupae by the peculiar recurving of the legs against the ventral surface of the base of the abdomen and the posterior portion of the thorax (Chironomidae). The terrestrial species are distinguishable from brachycerous forms by the very long antennal sheaths which curve over the upper margin of the eyes;

whereas in the Brachycera they are either short and inconspicuous or project almost in a straight line across the front of the head, being usually armed with thorns, or they project divergently downward and are frequently armed with strong thorns. The abdomen has usually 7 pairs of lateral spiracles, but in most of the aquatic forms these are not distinguishable.

Division Brachycera

As mentioned under the previous heading, the pupae of this group very frequently have spines on the antennal sheaths and, in addition, similar spines on protuberances on the face or other portions of the head, and also on the thorax. The prothoracic spiracles are sessile or but slightly elevated except in some Empididae and Dolichopodidae. The abdomen has 7 pairs of lateral spiracles; the segments usually have girdles (1-2) of spines, thorns, or hairs; and the apical segment is usually armed with two or more strong terminal spines or stout processes. Only in the case of the Stratiomyiidae are the pupae enclosed in the last larval skin.

The pupae of Coleoptera and Hymenoptera may readily be separated from those of Diptera by the mandibulate mouth-parts and the presence of four wing-pads, while the latter character will also separate those of Lepidoptera, though usually the under wings, or posterior wings, are visible only in the form of a narrow strip along the caudal margins of the front pair.

Suborder CYCLORRHAPHA

Divisions Acroptera, Aschiza, and Schizophora

All the divisions of this suborder may be distinguished by the fact that the pupae are enclosed within the indurated last larval skin. The absence of a well-developed head will readily separate the puparia of this suborder from those of Stratiomyiidae; in the case of Lonchopteridae, which resemble the latter family, there is no distinct head, there are only 9 distinct segments, and on the dorsum of the second abdominal segment there are horn-like respiratory organs as in Phoridae. The chitinized structure of the puparia itself will serve to separate them from those of the Cecidomyiidae that pupate under similar conditions, the integument of the latter being of a rather flimsy nature.

In Lonchopteridae, Syrphidae, Phoridae, and many Muscidae and Anthomyiidae a pair of thoracic respiratory organs are developed upon the first or second abdominal segment in the puparia. These organs do not appear until the pupa is formed, and their mushroom-like sprouting comes rather as a surprise to the observer.

Many species that ordinarily make primary, if not exclusive, use of the anal respiratory organs while in the larval stage make exclusive use of the prothoracic spiracles in the pupal stage. This is noticeably so in species that live under aquatic or semiaquatic conditions.

Keys to Suborders

LARVAE

1. Head complete, or the posterior portion with deep longitudinal incisions; mandibles moving horizontally.. *ORTHORRHAPHA-NEMATOCERA.*
— Head incomplete, without a strongly developed upper arcuate plate; mandibles moving vertically.....................................2
2. Maxillae well developed, their palpi distinct; mandibles normally sickle-shaped, not protruded much beyond the apices of the maxillae, often extending less than half-way to their apices; antennae well developed, situated upon the upper surface of a slightly arcuate chitinized dorsal plate.. *ORTHORRHAPHA-BRACHYCERA.*
— Maxillae poorly developed, their palpi visible only in a few groups; mandibles short and hook-like, usually capable of protrusion much beyond apices of maxillae if these are present; antennae poorly developed or absent, when present situated upon a membranous surface ....*CYCLORRHAPHA.*

PUPAE

1. Pupa not enclosed within the indurated last larval skin, or if so the head is distinct as in the larva, or the puparium is slightly flattened dorso-ventrally, its texture leathery, not chitinous, and the anterior respiratory organs not distinguishable; imago, or pupa, emerges through a rectangular split on dorsum of larval skin... *ORTHORRHAPHA*
— Pupa enclosed within the indurated last larval skin; head always retracted, the chitinous portion occupying a position on the inner side of the ventral surface of the puparium; anterior respiratory organs distinct, either protruded from the antero-lateral angles of the cephalic extremity or from dorsum of base of abdomen; imago usually emerges by forcing off the rounded anterior extremity of the puparium in cap-like form, or the dorsal half of the thoracic portion—the lines of cleavage being along the lateral margins to a point at base of abdomen; rarely emergence is through rectangular splitting of the dorsum of the puparium... *CYCLORRHAPHA.*

IMAGINES

1. Antenna consists of a 2-jointed scape—the basal joint usually indistinct—and a distinctly segmented flagellum of more than 2 joints .... *ORTHORRHAPHA*, pt.
— Antenna consists of apparently 2 or 3 joints and, usually, a terminal or dorsal arista 2
2. Frontal lunule absent .... *ORTHORRHAPHA*, pt.
— Frontal lunule present, or if poorly developed or apparently absent there are no distinct cross-veins on disc of wing .... *CYCLORRHAPHA*.

Suborder *ORTHORRHAPHA*

Keys to Divisions

LARVAE

1. Head complete, or sometimes incomplete posteriorly; mandibles absent or vestigial in Cecidomyiidae, but the body consisting of 13 segments in addition to the head, in other families mandibles present, moving horizontally or nearly so, their position when at rest being on a horizontal plane, or varying but slightly from it, their apices opposed; labium usually well developed, in the form of a flat plate with or without dentate anterior margin; larvae frequently peripneustic, the aquatic forms usually with protrusive anal blood-gills .... NEMATOCERA (p. 182).
— Head always incomplete and partly retracted within the prothorax; mandibles moving vertically, their position when at rest vertical, the apices parallel and directed downward; labium poorly developed, rarely or never in the form of a flat plate; larvae normally amphipneustic or metapneustic, very rarely peripneustic, aquatic forms without protrusive anal blood-gills .... BRACHYCERA (p. 307).

PUPAE

1. Head, except in some Cecidomyiidae and a few Tipulidae, without strong thorns; antennae much elongated, always very distinctly traceable, normally curved well over upper margin of eyes and extending to or beyond base of wing, in some cases almost to apex of wing; thoracic respiratory organs much elongated or sessile; legs of variable length, often extending to apex of abdomen, rarely slightly longer than wings, in aquatic forms often recurved against base of abdomen; abdomen in species with short antennae sometimes unarmed .... NEMATOCERA (p. 182).
— Free except in Stratiomyiidae; head in other families usually with

strong thorns, or if these are absent the antennae are very short and project downward and outward and do not curve over the upper margin of the eye or reach nearly to base of wing; thoracic respiratory organs sessile, rarely stalk-like; legs of variable length; abdomen usually armed with strong spines or bristles, or if unarmed there are only 4 or 5 distinct pairs of abdominal spiracles.............................BRACHYCERA (p. 307).

IMAGINES

1. Antenna consisting of at least 7 joints, frequently filiform, rarely conspicuously thickened, but if so the joints are distinct and the flagellum does not appear as a single joint with poorly defined subdivisions, and the palpi are pendulous, consisting of 4 or 5 joints; antennae with or without whorls of hair on the joints, never with a terminal arista or style; palpi always pendulous, normally consisting of 4 or 5 joints, very rarely of only 2...... ....NEMATOCERA (p. 182).

— Antennae consisting of 3 joints, the third occasionally having more or less distinctly annulated subdivisions, but in such cases the palpi are porrect and consist of 1 or 2 joints; antennae with short pubescence or with thick branches, in some families with either a terminal or subterminal style or arista; palpi projecting forward, consisting of 1 or 2 joints............BRACHYCERA (p. 307).

Division NEMATOCERA

TABULAR ARRANGEMENT OF FAMILIES

My present grouping of the Nematocera is as follows.

*Tribes**	*Superfamilies*	*Families*
Polyneura	Tipuloidea	Tipulidae Limnobiidae Ptychopteridae Rhyphidae
Eucephala	Mycetophiloidea	Bolitophilidae Mycetophilidae Sciaridae Macroceridae Platyuridae
	Culicoidea	Psychodidae Blepharoceridae Culicidae Dixidae
	Chironomoidea	Ceratopogonidae Chironomidae Orphnephilidae
Oligoneura	Cecidomyioidea	Cecidomyiidae
	Bibionoidea	Bibionidae Scatopsidae Simuliidae

The sequence of the families in the keys is not in accordance with the above list, the keys being framed to facilitate identification and not to indicate affinities.

*Tribe in this paper does not have the application given to it in contemporary papers, but has that which Brauer gave it. He used it to designate his subdivisions of the larger divisions of Nematocera, etc.

Keys to Families

LARVAE

1. Head incomplete; thorax and abdomen combined consisting of 13 segments; larvae peripneustic; usually with a chitinized plate (very distinct in mature larvae) on ventral surface of second thoracic segment.......................Cecidomyiidae (p. 293).
— Without the above combination of characters..................2
2. Head and thoracic and first and second abdominal segments fused; larvae with minute abdominal spiracles; abdomen with a ventral longitudinal series of sucker-like discs........................ ....Blepharoceridae (p. 274).
— Head free, or if retracted within or fused with prothoracic segment the other thoracic segments are distinct.......................3
3. Head complete, enclosing first ganglion; mandibles opposed......5
— Head incomplete posteriorly, either with 3 deep wedge-shaped slits, 2 on dorsum and 1 on venter, or the ventral surface very poorly chitinized and the dorsal one posteriorly in the form of 4 slender heavily chitinized rods, with a weakly chitinized divided plate on anterior half of the dorsum..................................4
4. Apical abdominal segment with 6 radiating protuberances, which are rarely poorly developed but frequently unequally so; body segments with regularly placed bristles, as shown in Figure 1, Plate XXVIII; head heavily chitinized, dorsally slightly arcuate and with 2 longitudinal slits, ventrally slightly rounded and with a central slit; antennae longer than maxillary palpi; labium pointed, not divided into 2 plates, the anterior margin dentate; mandibles very stout, with only 2 teeth (at apex) in species without apical processes.........................Tipulidae (p. 191).
— Apical abdominal segment with at most 5 radiating teeth, or if 6 are present the labium is subdivided centrally; body usually without regularly placed bristles, frequently with dense surface pilosity; head sometimes weakly chitinized and without distinct labium; antennae sometimes short and slender and not as long as maxillary lobe (not palpus); labium frequently subdivided into 2 plates; mandibles never with only 2 teeth. Limnobiidae (p. 207).
5. Thoracic segments fused and dilated, forming a complex mass.... ....Culicidae (p. 276).
— Thoracic segments not fused, distinct..........................6
6. Larvae peripneustic, or with at least rudimentary abdominal spiracles 7
— Larvae amphipneustic or metapneustic.......................12
7. Larvae with rudimentary abdominal spiracles; mouth with a large articulated process on each side which bears a number of long hairs and closes, fan-like, when at rest; posterior abdominal segments dilated, the last one armed on venter with a sucker-like disc which bears concentric series of bristles, by means of which the

larvae retain their hold upon rocks, etc., in the streams where they are found..........................Simuliidae (p. 302).

— Larvae with distinct though sometimes small abdominal spiracles; mouth without fan-like processes; posterior abdominal segments not noticeably dilated, the last without sucker-like disc; terrestrial species 8

8\. Antennae elongate; body armed with conspicuous bristles or hairs 9

— Antennae usually short and inconspicuous, sometimes apparently absent; body without conspicuous bristles..................10

9\. Anal spiracles at the apices of a pair of long stalk-like processes.... ....Scatopsidae (p. 300).

— Anal spiracles not noticeably elevated, situated near base of dorsal surface of apical segment................Bibionidae (p. 298).

10\. Dorsal, or clypeal, sclerite of head not conspicuously tapered posteriorly; antennae well developed......Bolitophilidae (p. 247).

— Dorsal, or clypeal, sclerite of head conspicuously tapered posteriorly; antennae almost indistinguishable................11

11\. Lateral sclerites of head meeting on ventral line only for a short space immediately caudad of mouth-opening, not connected at posterior margin...................Mycetophilidae (p. 248).

— Lateral sclerites of head connected for a very short space behind mouth-opening and again near posterior margin............... ....Sciaridae (p. 258)

12\. Dorsal surface of first and second abdominal segments each with 2 wart-like elevations somewhat resembling pseudopods, the apices of which are armed with numerous small hook-like setae; larvae aquatic, amphipneustic.....................Dixidae (p. 279).

— Dorsal surface of first and second abdominal segments without elevated processes 13

13\. All or some of the dorsal segments with narrow, chitinized, strap-like transverse bands, or the apical segment in the form of a short chitinized tube; rarely the ventral abdominal segments bear a central series of sucker-like discs.......Psychodidae (p. 264).

— Dorsum without narrow, chitinized, strap-like bands, apical segment not in the form of a short chitinized tube; ventral abdominal segments never with sucker-like discs.........................14

14\. Apical abdominal segment with long, slender respiratory tube.... ....Ptychopteridae (p. 238).

— Apical abdominal segment without long respiratory tube........15

15\. Antennae undeveloped, appearing as pale round spots on sides of head; ventral surface of head with the sclerites contiguous anteriorly, widely separated posteriorly.........................16

— Antennae pedunculate, usually well developed; ventral surface of head with sclerite contiguous on entire length, not separated widely posteriorly 17

16. Head subquadrate; abdominal segments with a number of rounded transverse ridges........................PLATYURIDAE (p. 260).
— Head elongate; abdominal segments without transverse ridges.................................... MYCETOPHILIDAE (p. 248).
17. Abdominal segments not subdivided............................18
— Abdominal segments subdivided by means of transverse constrictions 19
18. Larva very slender, tapering towards the extremities, without thoracic or anal pseudopods or surface hairs except about 8 at apex of abdomen, aquatic in habit; or stout, with well-defined segments which are armed with strong bristles, some of which are lanceolate; pseudopods present; terrestrial, living in manure or under bark, etc.....................CERATOPOGONIDAE (p. 281).
— Larva rarely very slender, generally of an almost uniform thickness, rarely with the thoracic segments appreciably swollen but not fused; abdominal and thoracic segments frequently with rather noticeable soft hairs, the last segment almost invariably with a conspicuous tuft of hairs on dorsum near apex; pseudopods almost always present, sometimes only the thoracic one distinguishable in terrestrial forms–which are very rare..CHIRONOMIDAE (p. 284).
19. Body slender, tapering; abdominal segments each with a single constriction near anterior margin; apical segment either with 5 short terminal processes or without distinct processes...RHYPHIDAE (p. 241).
— Body stout, of uniform diameter; abdominal segments each with 2 distinct constrictions; apical segment with 4 rather long processes, the lower pair longer than the upper..LIMNOBIIDAE, pt. (p. 207).

PUPAE

1. Head with several strong thorns in a vertical series on the median line; pupae enclosed within galls on various parts of plants.................................... CECIDOMYIIDAE, pt. (p. 293).
— Head without strong thorns, or if at base of each antenna there is a protuberance it is not sharp and thorn-like, and the pupae are not enclosed in galls on living plants........................2
2. Pupa enclosed within a tough, parchment-like envelope consisting of the hardened larval skin, which resembles a muscid puparium.................................. CECIDOMYIIDAE, pt. (p. 293).
— Pupa free, or if enclosed it is within a cocoon which is not parchment-like and does not resemble a muscid puparium...........3
3. Thoracic respiratory organs sessile; abdomen without strong thorns or leaf-like elevations; legs straight..........................4
— Thoracic respiratory organs stalk-like, or if sessile the abdomen has strong thorns or leaf-like elevations, or the legs are recurved against base of abdomen and apex of thorax, or the coxae do not

conceal the sternopleura and the scape of the antennae is almost globose; legs straight or recurved..........................8

4. Legs short, apices of hind tarsi projecting slightly beyond apices of wings; antennae short, curved across middle of eye...BIBIONIDAE (p. 298).

— Legs elongate, usually all tarsi projecting for a considerable distance beyond apices of wings; antennae elongate, extending to or beyond bases of wings.................................5

5. Antennae almost straight, noticeably flattened, extending to bases of wings; thorax not much swollen in front, its anterior profile not declivitous....................PLATYURIDAE (p. 260).

— Antennae distinctly curved, not flattened, extending beyond bases of wings 6

6. Thorax conspicuously swollen, almost globose, its anterior profile declivitous; sternopleura concealed......MYCETOPHILIDAE (p. 248).

— Thorax not conspicuously swollen, the anterior profile not declivitous...7

7. Scape of antennae much swollen, globose; abdominal spiracles small or absent; sternopleura remarkably enlarged, not concealed by fore coxae and femora................CHIRONOMIDAE (p. 284).

— Scape of antennae not much swollen; abdominal spiracles distinct; sternopleura not visible, concealed by the large coxae and femora of the fore legs..................CECIDOMYIIDAE, pt. (p. 293).
SCIARIDAE, pt......(p. 258).

8. Thoracic respiratory organs slender, long, and tube-like; legs straight, extending well beyond apices of wings; body without armature except a pair of hairs on anterior margin of head; sternopleura concealed............CECIDOMYIIDAE, pt. (p. 293).
SCIARIDAE, pt......(p. 258).

— Species without the above combination of characters, abdomen usually with hairs or spines, or the sternopleura is exposed.....9

9. Pupa in a pocket- or slipper-shaped cocoon consisting of coarse threads, from the wide, open extremity of which project the thoracic respiratory organs, each of the latter consisting of 4 to 60 tube-like branches on a common base; rarely the cocoon is a mass of rather loose threads...............SIMULIIDAE (p. 302).

— Pupa free, or if enclosed or partly so the cocoon is not pocket-like and the respiratory organs do not consist of tube-like branches.10

10. Pupa when seen from above oval in outline, the abdomen at base not conspicuously narrower than thorax, so that the lateral outline is continuous; dorsal surface with very strong, almost chitinized, membrane...11

— Pupa with the abdomen well differentiated from thorax, the dorsum membranous, or if strong and almost chitinized, then with surface spines..12

11. Thoracic respiratory organs lamelliform, consisting of 4 flat plates, the broad sides of which are contiguous..BLEPHAROCERIDAE (p. 274).
— Thoracic respiratory organs simple, tube-like..PSYCHODIDAE, pt. (p. 264).
12. Apical abdominal segment terminating in 2 or 4 paddle- or fin-shaped organs which are fringed on all or a part of their outer surfaces with strap-like hairs; or if the apical segment terminates in 2 long subconical processes the tarsi are, as in the other group, recurved against the ventral surface of the base of abdomen and apex of thorax so that they do not extend beyond the apices of wings..13
— Apical abdominal segment obtuse, armed with short or elongate spines or thorns, or if ending in a pair of long, slender processes these are more or less oval or circular in transverse section and without strap-like hairs; tarsi generally entirely straight, rarely the apices of the hind pair incurved slightly, but they are never recurved as above..18
13. Thoracic respiratory organs terminating in numerous thread-like filaments..........................CHIRONOMIDAE, pt. (p. 284).
— Thoracic respiratory organs consisting of a single stem, in some cases with a few long, or many short, scale-like surface hairs, but never terminating in numerous thread-like filaments; or occasionally the thoracic respiratory organs are not elevated.......14
14. Thoracic respiratory organs not elevated, sternopleura exposed....................................CHIRONOMIDAE, pt. (p. 284).
— Thoracic respiratory organs conspicuously elevated.............15
15. Thoracic respiratory organs situated close to anterior margin of thorax; thorax and abdomen without stellate hairs...CHIRONOMIDAE, pt. (p. 284).
— Thoracic respiratory organs situated close to middle of thoracic dorsum..16
16. Apical abdominal segment ending in 2 or 4 broad, flat, paddle-like plates...........................CULICIDAE, pt. (p. 276).
— Apical abdominal segment ending in 2 long subconical processes..17
17. Apical processes armed at apices and on middle of their outer margin with short hairs (3:1).............CULICIDAE, pt. (p. 276).
— Apical processes unarmed.......................DIXIDAE (p. 279).
18. Apices of legs not extending beyond apices of wings............19
— Apices of posterior legs at least extending beyond apices of wings..20
19. Apical abdominal segment ending in 2 conical processes...CERATOPOGONIDAE (p. 281).
— Apical abdominal segment ending in 2 upper and 2 lower short thorns..........................PSYCHODIDAE, pt. (p. 264).

20. Thoracic respiratory organs long, bifid; apical abdominal segment rounded, without processes; abdominal spiracles pedunculate.... ....SCATOPSIDAE (p. 300).
— Thoracic respiratory organs simple; apical abdominal segment not rounded, generally armed with protuberances...............21
21. Thoracic respiratory organs elevated but little above the level of disc of thorax; tarsi of the fore legs overlapping those of mid pair, the latter overlapping those of hind pair, all rather closely fused together and to wings...................RHYPHIDAE (p. 241).
— Thoracic respiratory organs very conspicuously elevated; legs not as above 22
22. Thoracic respiratory organs equal in length, rarely with one twice as long as the other; anterior, middle, and posterior tarsi distinct 23
— Thoracic respiratory organs of conspicuously unequal length, one many times as long as the other; anterior tarsi overlapping middle pair...........................PTYCHOPTERIDAE (p. 238).
23. Abdominal segments each with 1 transverse row, sometimes 2 such rows, of thorn-like protuberances; palpi recurved at apices...... ....TIPULIDAE (p. 191).
— Abdominal segments rarely with distinct thorn-like protuberances, usually with weak hairs; palpi straight, not recurved at apices.. ....LIMNOBIIDAE (p. 207).

IMAGINES

1. Wing with at least 9 veins extending to the margin (exclusive of the anal vein); if there are only 8 such veins the radius is 3-branched, the second branch having its base proximad of the radio-medial cross-vein 2
— Wing with less than 9 veins extending to the margin, or the venation not as above...8
2. Mesonotum with a more or less distinct V-shaped suture; male hypopygium generally very large, chitinous; female ovipositor conical, chitinized, and generally protruded.................3
— Mesonotum without distinct suture, or if there is a poorly defined suture it is not V-shaped.................................5
3. Wing with 2 anal veins...4
— Wing with 1 anal vein................PTYCHOPTERIDAE (p. 238).
4. Last palpal joint slender, much longer than the combined lengths of the 3 preceding joints; auxiliary vein terminating in first vein... ....TIPULIDAE (p. 191).
— Last palpal joint at most but little longer than the combined lengths of the preceding joints; auxiliary vein usually terminating in costa, connected with first vein by a cross-vein................ ....LIMNOBIIDAE (p. 207).
5. Costa continued around the hind margin of the wing............6
— Costa discontinued at apex of wing......RHYPHIDAE, pt. (p. 241).

6. Wing veins without conspicuous scale-like hairs. . DIXIDAE (p. 279).
— Wing veins with conspicuous scale-like hairs....................7
7. Wings short and broad, ovate, occasionally pointed apically; tibiae without apical spurs; small, robust species with rather short densely haired legs....................PSYCHODIDAE (p. 264).
— Wings elongate, narrow; tibiae with apical spurs; rather large, slender species, with long, slender, usually moderately hairy or scaly legs.................................CULICIDAE (p. 276).
8. Wing with 2 to 4 distinct longitudinal veins...CECIDOMYIIDAE (p. 293).
— Wing with 5 or more longitudinal veins.......................9
9. Wings with a secondary reticulation of fine creases or lines in addition to the veins; slender tipulid-like species with long slender legs...........................BLEPHAROCERIDAE (p. 274).
— Wings without a secondary reticulation of fine creases, at most with a longitudinal furcate crease between media and cubitus......10
10. Abdomen in both sexes with a conspicuous flap-like scale at base of dorsal surface which is detached posteriorly and fringed with long hairs............................SIMULIIDAE (p. 302).
— Abdomen without such basal process..........................11
11. Second basal cell of wing present............................12
— Second basal cell of wing absent.............................13
12. Antenna consisting of 2 stout joints, and an apical arista-like one composed of 9 or 10 segments.........ORPHNEPHILIDAE (p. 290).
— Antenna composed of 10–11 joints, the apical portion stout, not differentiated arista-like....................BIBIONIDAE (p. 298).
13. Antenna consisting of 10–11 joints in both sexes (10 if scape is regarded as consisting of 1 joint), the joints of central portion of flagellum shorter than broad; radius and costa conspicuous, the other veins indistinct; at least the mid and hind tibiae without apical spurs.........................SCATOPSIDAE (p. 300).
— Without the above combination of characters.................14
14. Coxae unusually elongated.......................................15
— Coxae not unusually elongated................................19
15. Radius with 3 branches; medio-cubital cross-vein present........16
— Radius with only 2 branches, or if there are three present the medio-cubital cross-vein is absent...........MYCETOPHILIDAE (p. 248).
16. Radio-medial cross-vein present, causing the base of the first posterior cell to be more or less broadly truncate.................17
— Radio-medial cross-vein apparently absent, fused with base of third branch of radius so that the base of first posterior cell is acute.18
17. Medio-cubital cross-vein much proximad of the radio-medial, causing the posterior portion, divided longitudinally by media, to be much shorter than the anterior portion. . BOLITOPHILIDAE (p. 247).
— Medio-cubital cross-vein almost directly in vertical line with the radio-medial, the 2 cells divided longitudinally by media subequal in length.......................RHYPHIDAE, pt. (p. 241).

18. Antennae short, thick, and often flattened...PLATYURIDAE (p. 260).
— Antennae very long, usually exceeding in length that of body, very slender..............................MACROCERIDAE (p. 260).
19. Mouth parts chitinized, constructed for piercing, not in the form of a long slender process..............CERATOPOGONIDAE (p. 281).
— Mouth parts not chitinized, fleshy, sometimes in the form of a long slender process 20
20. Radius with 2 branches......................SCIARIDAE (p. 258).
— Radius with 3–4 branches, if less or indistinct the antennal joints with very long plumes in the male and very conspicuous constrictions between them in the female.......CHIRONOMIDAE (p. 284).

Tribe POLYNEURA

I have included in this tribe, as I regard it, but one superfamily, Tipuloidea, containing the families Tipulidae, Limnobiidae, Ptychopteridae, and Rhyphidae. Brauer limited his tribe Polyneura to Tipulidae (inclusive of Limnobiidae), placing the other two families in Eucephala.

I have placed this tribe first in my arrangement because I consider the adults much more primitive structurally than the most generalized forms in the other groups. The larvae undoubtedly show more specialization than do those of Mycetophiloidea both in the structure of the head, if we accept the capsule as the criterion, and in the respiratory system, but I find that the larvae of many closely allied species in different families show quite striking distinctions even though the adults are almost inseparable, and therefore have decided to consider the tribe as more generalized than the others. The sequence of families does not show an unbroken line, but, rather, represents a series of divergent lines of varying lengths, no two of which start from a common point.

Superfamily *Tipuloidea*

SUPERFAMILY CHARACTERS

Larva.—Head incomplete posteriorly, wholly or partly retractile, or if the head is complete the abdomen has the anterior 6 segments subdivided, or the posterior respiratory tube is much elongated and membranous, and distinct paired ventral pseudopods are present on anterior half of body. Head with opposed mandibles; antennae well developed.

Pupa.—Head without conspicuous armature except in some Limnobiidae; antennae elongate, curved over upper margin of eyes. Wings and legs closely fused to thorax, the former very short, the latter never extending to apex of abdomen; thoracic respiratory

organs usually elevated, one of them much longer than the other in Ptychopteridae, the two normally of equal length and usually slender in Tipulidae, ear-like, appearing like vertical plates, in some Limnobiidae, while in Rhyphidae they are but little elevated and rather stout. Abdomen in Rhyphidae and most Tipulidae circular in cross-section, usually with 2 transverse series of more or less leaf-like or thorn-like protuberances on each segment.

Imago.—Distinguishable from all other Nematocera by the presence of the discal cell of wing. *Mycetobia* has no discal cell. This genus has been placed by most writers in the Mycetophiloidea, but lately its affinities with Rhyphidae have been considered closer, and Edwards traces in the presence of a well-defined gular plate a distinct connection with that family, this plate being almost invariably absent in Mycetophilidae, and even when present differing materially from that of *Mycetobia.* The venation of the *Mycetobia* wing differs from that of Mycetophilidae in that the second branch of the radius has its base proximad of the radio-medial cross-vein instead of distad of it. The female of *Mycetobia* has chitinized spermathecae, this character separating it from Mycetophilioidea, no genus of which possesses them. Some Tipulidae have no discal cell, but they all have a distinct V-shaped suture on the dorsum of the thorax—a character which distinguishes them from other Nematocera. Ptychopteridae possesses an incomplete V-shaped or slightly sinuous thoracic suture, and in common with related Nematocera, except Rhyphidae, has very long legs, slender wings, and a long slender body.

Allocation of species of the families must be arrived at by using the key to families of the Nematocera on a previous page.

Family *TIPULIDÆ*

This family as limited in the present paper contains only three subfamilies: Dolichopezinae, Ctenophorinae, and Tipulinae. Only the two last named are known to me in their immature stages. The number of species of Ctenophorinae in North America is small, but the genus *Tipula,* in Tipulinae, contains a very large number of species, the larvae, pupae, and imagines of which in very many cases bear a striking resemblance to each other. With the present collection it is not possible for me to do more than to indicate the principal characters useful in distinguishing the larvae and pupae from each other and from those of other families.

FAMILY CHARACTERS

Larva.—Head heavily chitinized, retractile within prothorax; posterior portion deeply cleft longitudinally, one incision on each side of dorsum extending to, or almost to, middle, and one in center of venter extending beyond middle. Antennae elongate, consisting of an elevated base, an elongate joint—in *Tipula* at least four times, in *Xiphura* not more than twice, as long as broad—and a very short apical process. Front and clypeus fused, the former with a distinct plate on each side, the anterior margin of which is armed with a few bristles and many hairs; labrum fringed with hairs anteriorly; epipharynx with a number of spines or short processes. Maxillae well developed, fringed on the inner and anterior margins with hairs, and sometimes spinose; palpi small. Mandibles stout, the apex rounded and with 2 teeth more or less equal in size, lower margin with 2 or more teeth, inner upper margin with a fringe of hairs near middle. Labial plate (submentum) in the form of a flat plate, its outline medianly produced into an acute point anteriorly, the margin more or less distinctly dentate. Hypopharynx heavily chitinized, in the form of a flat plate the anterior margin of which is usually dentate, and with a posterior inverted-U-shaped chitinized piece which arches over the oesophageal opening. Body cylindrical; segments usually with distinct hairs which are situated on certain portions of each segment, their arrangement being uniform throughout the family; pseudopods present or absent; segments always with transverse linear depressions, most distinct on dorsum; apical segment with 6 processes, rarely without these being well developed; ventral surface of apical segment in aquatic and semiaquatic species with fringes of soft hairs on apical processes and with slender protrusive blood-gills; terrestrial forms with the fringes of hairs much reduced or absent, and the slender protrusive blood-gills usually absent, their function being performed by an irregular protrusive membranous organ.

Pupa.—The pupae differ from those of Limnobiidae in minor characters only, the principal distinction between them and pupae of the genus *Limnobia* and several other genera consisting in the form of the thoracic respiratory organs, those of Tipulidae, exclusive of Ctenophorinae, being long and slender, while those of the other family are stout and resemble a chitinized flattened plate. Many of the Limnobiidae, however, have slender thoracic respiratory organs, and other characters must be depended upon to distinguish them from Tipulidae. A brief summary of the characters of tipulid pupae is as follows: head without projecting chitinized armature; antennae

never swollen at bases; thoracic respiratory organs slender, of moderate length, sometimes slightly swollen at apices—except in Ctenophorinae, in which they are heavily chitinized, flattened, and highly glossy; legs exceeding the wings in length. Abdomen with 1 or 2 transverse series of short protuberances on each segment except basal and apical. Palpi recurved at apices.

Imago.—See synopsis of families.

HABITS OF LARVAE

Most of the larvae are scavengers, feeding on decaying vegetation, in mud containing vegetable debris, or in rotten wood. Occasionally some species of *Tipula* cause injury to crops such as oats and hay, or to pastures, by feeding upon the roots of the growing plants. Many of the species are aquatic or semiaquatic, living among floating vegetable matter along the margins of ponds or streams. The food consists of algae and various kinds of vegetable matter.

HABITS OF IMAGINES

The imagines occur commonly in damp situations, especially where there is a rank growth of vegetation. They feed upon nectar of flowers and upon moisture on vegetation and on the ground. Many of the species are readily attracted to lights.

Keys to Subfamilies

LARVAE

1. Mandibles with 2 teeth; antennae about twice as long as broad.. Ctenophorinae.
— Mandibles with more than 3 teeth; antennae about 4 times as long as broad................................. Tipulinae.

PUPAE

1. Thoracic respiratory organs broad, glossy, and heavily chitinized (Pl. XXXII, Fig. 20)........................ Ctenophorinae.
— Thoracic respiratory organs slender, opaque, not more heavily chitinized than dorsum of thorax.................. Tipulinae.

IMAGINES

1. Legs very long and slender, the tarsi especially so; anterior branch of second vein absent, indistinguishable, or perpendicular.. Dolichopezinae.

— Legs long but not very slender; anterior branch of second vein present, oblique 2
2. Antennae of male pectinate or subpectinate.......CTENOPHORINAE.
— Antennae not pectinate.................................TIPULINAE.

Subfamily CTENOPHORINAE

I have before me only a part of a larval exuvium—consisting of the head—and the pupal exuvium of one species of this subfamily, and am consequently unable to give a detailed description of the immature stages. The specimens, however, present characters that serve to distinguish at least this species from other Tipulidae known to me. As the characters of the species I have may not be in agreement with those of other genera in the subfamily, unknown to me, I shall restrict my generalizations to the genus to which it belongs.

XIPHURA Brullé

GENERIC CHARACTERS

Larva.—Head large, heavily chitinized, arcuate on dorsum. Antennae short and stout, longer than maxillary palpi. Mandibles very stout, without teeth along the lower margin. Labial plate heavily chitinized, similar in general form to that of *Tipula*. Maxillae well developed, the palpi short and stout. Hypopharynx similar in form to that of *Tipula*. Structure of body not known to me. The parts of the exuvium that remain show that there are numerous long surface hairs present as in *Tipula*, and the anal spiracles are large, slightly elevated, pale brown, with the central opening darker.

Pupa.—Head without protuberances between antennae; bases of antennae slightly swollen; labium rather prominently protruded. Thoracic respiratory organs heavily chitinized, glossy, irregularly and coarsely wrinkled; apices of tarsi except those of the fore pair extending much beyond apices of wings. Abdomen with a single encircling series of short broad processes on each segment, the apices of which are acutely pointed.

HABITS OF LARVAE

All of the known larvae of this subfamily live in much-decayed trees, but whether they feed upon the dead wood or some vegetable growth it contains, or upon insect larvae is unrecorded.

HABITS OF IMAGINES

The imagines feed upon nectar and sap. They are usually rare, and normally occur in proximity to a suitable larval habitat.

XIPHURA FUMIPENNIS Osten Sacken

Ctenophora fumipennis Osten Sacken, Proc. Ent. Soc. Phila., 1864, p. 47.

Larva.—Head black, heavily chitinized, antenna short and stout, with a very short apical appendage (Pl. XXXII, Fig. 21); mandibles very robust, with 2 strong apical teeth (Fig. 25); labium dentate along its anterior margin, the central tooth simple; hypopharynx as in Figure 23, Plate XXXII, the anterior margin transverse.

Pupa (Pl. XXXII, Fig. 24).—Length, 22 mm. Dark brown, slightly shining. Thoracic respiratory organs glossy black. Abdominal spines dark castaneous at bases, becoming pale at apices.

Head without protuberances, the organs in the same positions and of the same form as in *Tipula;* antenna extending beyond base of wing. Thoracic respiratory organs robust, about twice as long as their greatest width, heavily chitinized, their margins irregular (Fig. 20). Abdomen with strong leaf-like process at apices of segments, the tips of which are very acute; lateral margin of segments with the same armature as in *Tipula,* one simple process before spiracles and another, bifid, behind them; spiracles small but distinct; apical segment elongated, its apical half consisting of 2 long upper, and 2 shorter lower, processes.

The foregoing descriptions were made from the larval and pupal exuvia of a female specimen reared by Dr. H. Glasgow, June 8, 1910. The larva was found in a much-decayed chestnut log in the Augerville woods, Urbana, Ill.

Subfamily TIPULINAE

SUBFAMILY CHARACTERS

Larva.—Head heavily chitinized; antennae longer than maxillary palpi; mandibles stout; labium well developed, usually dentate; hypopharynx large. Body without surface pilosity or with very short and dense pile; arrangement of bristles as shown in Figure 1, Plate XXVIII. Apical segment with 6 finger-like processes, sometimes of very unequal length; spiracles large.

Pupa.—Head usually with 2 small membranous protuberances above bases of antennae; antennae not swollen at base, and often with

a small thorn; palpi recurved at apices. Thorax with or without short wart-like protuberances on dorsum; respiratory organs long and slender; halteres visible above upper margin of wing and resembling in certain respects the posterior wings in some lepidopterous pupae; legs greatly exceeding length of wings. Abdomen with 1, or 2, transverse series of thorns on ventral segments beyond apices of legs, the anterior series, if both are present, much weaker than the posterior; dorsal segments usually with a postmarginal series of thorns.

HABITS OF LARVAE

As far as known the larvae are scavengers, feeding upon decaying vegetable matter. Many species are aquatic or subaquatic.

HABITS OF IMAGINES

The imagines fly most readily in the late afternoon. The species I have observed in nature are flower frequenters.

Tipula Linné and Pachyrrhina Macquart

As very few of the species before me have been reared, and are represented only by larvae or pupae or, at most, by both, there is at present no possibility of specifically identifying these immature stages. Neither is it possible for me to cite characters for the separation of the larvae of *Tipula* and *Pachyrrhina*, the reared material at hand being quite insufficient to justify any attempt at a generalization. I give a synopsis of the characters that appear to me to be of primary importance in the separation of the forms I have studied, but, unfortunately, I can specifically identify only a very few of them, and as in my opinion detailed descriptions would occupy more space than their possible scientific value will warrant me in taking, only the notes and synopsis are presented. I leave this subfamily in this condition, however, with the hope that the work now being done by C. P. Alexander on the biology of the crane-flies will satisfactorily fill the very large gap in our knowledge of the early stages of the group.

A complete study of our material is not at present contemplated, the forms described in this paper being included merely as indices to the range of specific distinctions, and as adjuncts to the synoptic characters cited in the key to the families.

Keys to Species

LARVAE

1. Apical abdominal ventral segment with slender protrusive blood-gills 2

— Apical abdominal ventral segment with blood-gills in the form of an irregular protuberance, rarely acute laterally..............9

2. Ventral blood-gills not conspicuously longer than the stellate processes on margin of stigmatal field, these processes slender, regularly and very conspicuously fringed..............*Tipula* sp. 1.

— Ventral blood-gills conspicuously longer than stellate processes, or the latter not regularly and conspicuously fringed, or the processes very unequal in length..............................3

3. Stellate processes subequal in length, very short, their margins with regular fringe of short hairs..............................5

— Stellate processes very unequal in length, the upper two short, the lateral and lower ones much longer and with isolated groups of long hairs 4

4. Very large species, more than 40 mm. in length; penultimate abdominal segment with a lateral process................*Tipula* sp. 2.

— Small species, 20 mm. in length; penultimate abdominal segment without a lateral process........................*Tipula* sp. 2a.

5. Small species, not more than 30 mm. in length.................6

— Larger species, more than 40 mm. in length...................7

6. Body with dense pubescence which is most conspicuous on 2 narrow longitudinal lines on dorsum, giving the species the appearance of being vittate; posterior latero-ventral bristles surrounded with stiff upright hairs..............................*Tipula eluta.*

— Body without dense pubescent vittae; posterior latero-ventral bristles not surrounded with stiff upright hairs. *Tipula cunctans.*

7. Body almost regularly cylindrical, as in *eluta*; posterior latero-ventral bristles not on pseudopod-like elevations, their bases surrounded with short, stiff, upright hairs; dorsum not conspicuously vittate....................................*Tipula* sp. 4.

— Body not regularly cylindrical, the segmentation deep, and the posterior segments with distinct pseudopod-like elevations; posterior latero-ventral bristles situated on elevations and not surrounded with stiff upright hairs; dorsum conspicuously vittate 8

8. The pale dorsal vittae composed of a number of closely placed pale dots; dorsum with many small pale paired spots; hairs not inserted in dark brown dots.................*Tipula abdominalis.*

— The pale dorsal vittae linear; dorsum with a number of very inconspicuous pale dots; hairs inserted in dark brown dots. *Tipula* sp. 3.

9. Apical abdominal segment with a conical protuberance on each side proximad of the processes on the margin of stigmatal field (Pl. XXXI, Figs. 6, 7)...........................*Tipula* sp. 6.

— Apical abdominal segment without a protuberance on sides......10

10. Upper 4 processes on anal segment decurved, long, and pointed, much longer than lower pair, ventral respiratory organs acute laterally (Pl. XXXII, Figs. 7, 8); prothorax with 2 horny protuberances on its dorsal margin anteriorly.................*Tipula* sp. 5.

— Upper 4 processes on anal segment not decurved, usually straight; ventral respiratory organ not acute laterally; prothorax without horny protuberances on its dorsal margin anteriorly..........11

11. Upper median pair of processes on apical abdominal segment very acutely pointed, their posterior face glossy brown, lower pair very small and widely separated; hypopharynx with upper plate more acute than usual (Pl. XXXI, Fig. 14).............*Tipula* sp. 7.

— Upper median pair of processes on apical abdominal segment not acutely pointed, lower pair of moderate size and rather close together...12

12. Upper plate of hypopharynx with acute teeth, its anterior outline distinctly convex (Pl. XXXII, Fig. 13).........*Tipula bicornis.*

— Upper plate of hypopharynx with rounded teeth, its anterior outline almost transverse (Pl. XXXII, Fig. 15).................. ....*Pachyrrhina ferruginea.*

PUPAE

1. Thoracic respiratory organs very long and slender, one much longer than the other, the longest one at least half as long as entire body..*Tipula* sp. 1.

— Thoracic respiratory organs equal in length, not more than one fourth as long as entire body...............................2

2. Ventral abdominal segments beyond apices of tarsi with a median and apical transverse series of spines.......................3

— Ventral abdominal segments with only the apical series of spines.4

3. Antennae with a distinct but short thorn on outer side at base; frons slightly furcate and covered with irregular small wart-like protuberances between bases of antennae..........*Tipula cunctans.*

— Antennae without thorn at base; frons not as above...*Tipula eluta.*

4. No minute thorns or bristles laterad of the 2 strong thorns on third and fourth ventral abdominal segments; protuberance between base of antennae and base of thoracic respiratory organs small, forming a distinctly isolated wart-like prominence........... ....*Tipula trivittata.*

— One or two closely paired small thorns or 2 slender bristles laterad of the 2 strong thorns on third and fourth ventral abdominal segments; space between base of antennae and base of respiratory organs filled with a regularly rounded prominence...........5

5. Thoracic respiratory organs short, not extending more than halfway from their bases to medio-dorsal protuberances; 2 weak bristles laterad of the ventral series of thorns on abdominal segments; apical segment of female much elongated (Pl. XXVIII, Fig. 8) ....*Tipula serta?*

— Thoracic respiratory organs long, extending almost or quite to medio-dorsal protuberances; one or two small thorns laterad of

the series of thorns on ventral abdominal segments; apical segment of female not elongate.............................6

6. Apical abdominal segment drawn out into a long process consisting of an upper and a lower pair of tube-like organs (Pl. XXXII, Fig. 18)...................................*Tipula* sp. 7.

— Apical abdominal segment short and stout, not drawn out into a long process 7

7. Apical segment with 4 small but distinct lobes at tip (Pl. XXVIII, Fig. 6)............................*Pachyrrhina ferruginea.*

— Apical segment with 2 rather large lobes at tip (Pl. XXVIII, Fig. 7)...................................*Tipula bicornis.*

Tipula sp. 1

Larva.—Length, 20–22 mm. Dark brown, with an indistinct pale central vitta and slightly paler along sides.

Antennae about 4 times as long as their basal width, distinctly tapering apically; apical joint very small; frontal plate with a rather conspicuous tuft of hairs near outer anterior angle; labrum not conspicuously hairy; mandibles as in Figure 2, Plate XXXII; hypopharynx more elongate than in other species examined, its anterior margin with 3 rather large teeth in an almost transverse series and a much smaller one at angles (Pl. XXXII, Fig. 1); labium as in Figure 3, Plate XXXII. Body without surface pilosity; bristles very weak though long; latero-ventral bristle on posterior portion of each segment usually duplicated, sometimes triplicated; outer bristle of the transverse series on posterior portion of each of the dorsal segments duplicated; lateral bristles weaker than the dorsal and ventral series; apical segment as in Figure 8, Plate XXXI.

Pupa (Pl. XXVIII, Fig. 14).—Length of body, 15 mm.; that of longest respiratory organ, 9 mm. Dark brown, the lateral longitudinal elevation along the spiracular region pale; abdomen with dorsum indistinctly, and venter distinctly, bivittate.

Thoracic respiratory organs very slender, unequal in length, their apices flattened and split longitudinally; apices of fore tarsi falling short of apex of first abdominal segment beyond apices of wings, mid tarsi extending slightly beyond the apex of that segment, hind tarsi extending to middle of next segment. Exposed ventral abdominal segments, except apical, each with 2 series of thorns on posterior division, the anterior consisting of 2, widely separated, and the posterior of 4 to 14; no thorns on area covered by legs, and the next 2 series slightly interrupted at middle; apical segment with 4 long up-

wardly curved spine-like processes which are armed at apices with several short thorns.

The foregoing descriptions are made from a larva and pupa bearing the Laboratory accession number 26281, obtained by Dr. S. A. Forbes in Delavan Lake, Wis., May 25, 1892, taken in an inlet among weeds at the surface, and one larva, accession number 26282, taken by the same collector at the same place May 26, 1892.

The species is undoubtedly truly aquatic, judging from the structure of the apical segment. No means is at hand for associating the early stages with any described imago.

Tipula sp. 2

Larva (Pl. XXVIII, Fig. 2).—Length, 45–55 mm. Brown, without well-defined vittae (alcoholic specimens).

General structure as in above-cited figure. The principal differences in head structure between this species and the preceding lie in the shape of the labium and the hypopharynx, the former (Pl. XXXII, Fig. 5) having a strongly produced central tooth and no distinct laterals, while the latter (Pl. XXXI, Fig. 13) has the anterior margin with only 2 weak protuberances and no rounded teeth; frontal plate as in Figure 9, Plate XXXI. Body without close pubescence, the armature as shown in Figure 2, Plate XXVIII; abdominal segments with the posterior lateral bristles on both dorsum and venter situated on pseudopod-like elevations; apical segment as in Figure 3, Plate XXVIII.

The foregoing description was made from alcoholic specimens in the Laboratory collection bearing the following data: Accession number 25756, Urbana, May 7, 1888, taken in woods (C. A. Hart); and two examples submitted by J. A. Hyslop (acc. 6687) from Hagerstown, Md.

Tipula sp. 2a

This specimen may really be a young example of the foregoing, as it differs only in size (20 mm.) and in having a process on each side of the penultimate abdominal segment.

Locality, Blacktail Deer Creek, Yellowstone National Park, August 28, 1890; taken in an aquatic collection among vegetable debris (S. A. Forbes).

Tipula abdominalis Say

Ctenophora abdominalis Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 18. (1823)
Tipula abdominalis Say, Needham, Bull. 47, N. Y. State Mus., p. 575. (1901)

A larva which was assumed to be of this species was described by Needham, as cited above. The markings given in that description appear to justify me in considering the species following as distinct from *abdominalis*.

Tipula sp. 3

Larva.—Length when full-grown, 50 mm. Dark greenish brown, with 2 continuous moderately broad longitudinal vittae on dorsum, a dark brown median vitta, and a number of isolated pale dots; surface hairs set in small blackish or dark brown dots.

Head rather small in comparison with size of larva, lateral view as in Figure 4, Plate XXXII; antennae normal in size; labial plate (Pl. XXXII, Fig. 6) with one very large central tooth, with more or less distinct shoulders, and 3 smaller lateral teeth; hypopharynx (Pl. XXXI, Fig. 12) with anterior margin of upper plate slightly convex, the central tooth of the five the largest. Body similar in general structure to that of Species 2, but the apical segment very different, quite closely resembling that of Species 4 except that the ventral blood-gills are distinctly shorter and stouter.

Described from specimens obtained by Dr. S. A. Forbes in Blacktail Deer Creek, August 28, 1890, and in Slough Creek August 30, 1891—both in Yellowstone National Park.

Tipula sp. 4

Larva.—Agrees in general appearance and armature of the abdominal segments with *eluta*, but differs in being much larger (50 mm.) and in having the apical abdominal radiating processes much less acute (Pl. XXXI, Fig. 5). The head agrees closely with that of Species 3, the labium (Pl. XXXII, Fig. 9) and hypopharynx (Pl. XXXI, Fig. 15) being of the same general structure, differing only in having the former narrower and more acute anteriorly; fronto-clypeal region as in Figure 4, Plate XXXI; mandibles as in Figure 26, Plate XXXII.

Specimens are in our collection from Ithaca, N. Y. (March 21. 1897).

Tipula sp. 5

Larva (Pl. XXIX, Fig. 3).—Length, 27 mm. Separable from other species that do not have the long slender blood-gills on apical abdominal segment by a pair of slight elevations or tubercles on the dorsum of the anterior third of the prothoracic segment, and by the peculiar formation of the apical segment, shown in Figures 7 and 8,

Plate XXXII. The hypopharynx and labium agree with those of *Pachyrrhina ferruginea.*

I have before me the specimen from which Mr. Hart drew up his description of his Species (*b*) in the paper on the "Entomology of the Illinois River and Adjacent Waters"*, and a number of specimens sent in by a farmer October 7, 1915, from an alfalfa field at Towanda, Ill.

Tipula sp. 6

This is the Species (*a*) described by C. A. Hart in his paper on Illinois River species. The apical segment differs from that of any allied species known to me, and this character alone should enable one to identify it. As Hart did not figure this species I have prepared drawings of the apical segment which are presented herewith (Pl. XXXI, Figs. 6, 7).

In addition to the specimen previously recorded from Havana, Ill., I have before me one taken in a sandy swamp at Grand Crossing, Ill., Nov. 7, 1891 (C. A. Hart).

Tipula sp. 7

Larva.—Length, 25–30 mm. Brown, apical segment yellowish white on the posterior surface, the 4 upper radiating processes conspicuously blackened posteriorly, or on what is their inner or under surface when incurved, the lower pair with a black spot near apex which, because of the processes being normally curved upward, as in Figure 1, Plate XXXI, is not usually visible.

Head of normal size and shape, the dorsal and ventral surfaces as shown in Figures 2 and 3, Plate XXXI; hypopharynx as in Figures 11 and 14 of the same plate; mandibles as in Figure 27, Plate XXXII. Body with weak pilosity, the arrangement of bristles and the general structure as in *Pachyrrhina ferruginea;* apical segment differing as stated in key.

Pupa.—Length, 28–30 mm. Brown, slightly shining.

Base of antennae with a sharp thorn-like process on anterior side; a small rounded tubercle above and behind base of antennae. Thoracic respiratory organ about 10 times as long as its greatest width; post-spiracular and medio-dorsal thoracic protuberances large, the latter sharp and not bifiid, posterior protuberance small; legs ending just before apex of third abdominal segment, the apices of fore tarsi fall-

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, p. 217.

ing short of apices of mid pair. Two thorns on each side of third segment in line with apices of tarsi; 6 thorns on other segments, the lateral one of each series weakest; apical segment as in Figure 18, Plate XXXII.

This is the species described by C. A. Hart as Species (*e*) in the paper previously referred to. It occurs in humid earth and especially under logs or leaves. In addition to Hart's material I have before me two specimens from St. Clair Co., Ill. (Nov. 26, 1886).

Tipula eluta Loew

Tipula eluta **Loew, Bull. Ent. Zeitschr., 1863, p. 290.**

The external characters of this species have been very fully described by C. A. Hart in his paper on the "Entomology of the Illinois River and Adjacent Waters"*. The details given here are merely supplementary.

Larva (Pl. XXIX, Fig. 1).—Antennae about 4 times as long as basal width, slightly tapering apically; maxillary palpi longer than broad; labial plate with a large rounded central tooth, and 2 much smaller lateral teeth and 2 poorly developed protuberances on each side; hypopharynx similar to that of Species 4 (Pl. XXXI, Fig. 15). Lateral abdominal bristles as shown in Figure 1, Plate XXVIII.

Pupa (Pl. XXIX, Fig. 2).—Thorax with the postspiracular, medio-dorsal, and postero-dorsal protuberances small but distinct. Legs in female extending to apex of first abdominal segment beyond apices of wings, in male to middle of the next segment. Armature of ventral abdominal segments similar to that of Species 1 except that the second visible segment has the widely separated anterior pair of thorns reduced to mere hairs, and the other segments have these same thorns simple, with a small hair at base instead of 2 thorns as in that species; apical segment of sexes as in Figures 11, and 13, Plate XXVIII.

These descriptions and the figures are made from specimens used by Mr. Hart as a basis for his descriptions of *eluta* in the paper above referred to. The specimens were obtained from the Illinois River at and near Havana, Ill. The larva is usually found burrowing in the sand on the shore, but occasionally is found in the water. I have taken the larvae from wet mud and sand along the margin of a small stream at Muncie, Ill., and very probably the species occurs in similar situations throughout the state.

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 212–214. (1895)

Tipula cunctans Say

Tipula cunctans Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 23. (1823)

Larva.—Similar to the previous species in general appearance and structure, the principal distinctions being as follows: the fronto-clypeal region is less hairy, the plates on either side having only an isolated tuft of hairs at outer anterior angle and one bristle and a short thorn on inner anterior protuberant area; the labial plate (Pl. XXXII, Fig. 10) has 3 large teeth on each side of the central one; anterior outline of hypopharynx as in Figure 11 of same plate; the body is not densely pubescent, and shows no vittae on dorsum; and the short, stiff, upright hairs that surround the bristles in *eluta* are wanting.

Pupa.—Length, 18–22 mm. Reddish brown, lateral margins yellowish.

Slenderer than *eluta*. Head rather distinctly protuberant between antennae, the surface with coarse rugae and a few small warts; bases of antennae with a small sharp process on anterior surface. Area between base of antennae and respiratory organs regularly rounded; dorsum of thorax without the distinct protuberances so noticeable in *eluta*; apices of fore, mid, and hind tarsi not in a transverse line, but each successively farther beyond apices of wings. All of the exposed abdominal segments with 2 series of spines each, the anterior one consisting of 2, widely separated, and the posterior series of 4–12, closely placed; the third and fourth segments have the anterior pair of spines reduced to mere hairs; dorsal segments with only the posterior armature distinct; apical segment of female as in Figure 19, Plate XXXII, that of male as in Figure 22.

Described from examples in the collection obtained at Newton and Hillsboro, Ill., April 1896. The species is very common throughout the state and, like *T. bicornis,* is sometimes destructive in meadows, pastures, and other grass lands, the larvae feeding on the roots of the plants.

This species is usually found in quite different surroundings from those of *eluta,* being essentially terrestrial in habit and often found in fields which are rather dry and well removed from any body of water.

Tipula trivittata Say

Tipula trivittata Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 26. (1823)

Pupa.—Length, 22–25 mm. Dark brown, lateral line pale.

Bases of antennae with a sharp protuberance on anterior side; a

small but distinct elevated tubercle immediately behind antennal base. The usual 6 small elevations on dorsum of thorax, the medio-dorsal pair duplicated transversely; wings extending to apex of second abdominal segment; legs extending beyond apex of third, terminating in a straight transverse line. All dorsal segments except apical one with a transverse series of thorns on or near posterior margin, the series becoming successively stronger from basal segment to apical; postnotum with 4 very small protuberances; third and fourth ventral abdominal segments each with 2 widely separated thorns, fifth to eighth inclusive with 4 each; prespiracular and postspiracular spines of equal strength, both simple; apical segments of male and female as in Figures 16, and 17, Plate XXXII.

The foregoing description was made from exuvia supplied by Dr. E. P. Felt and J. A. Hyslop, the former obtaining his specimens at Albany, N. Y., May 5, 1909, and the latter obtaining his at Wolfville, Md., May 21, 1915. The species is represented in the Laboratory collections by two imagines from Algonquin, Ill.

Tipula serta Loew?

Tipula serta Loew, Berl. Ent. Zeitschr., 1863, p. 283.

Pupa.—Length, 30 mm. Yellowish brown. Robust. Head with a pair of small rounded elevations above and between bases of antennae; antennae without a distinct basal process. Thoracic respiratory organs less than 6 times as long as their greatest width; postspiracular protuberances in the form of rounded elevations; mediodorsal pair carinated, simple; tarsi terminating in a straight transverse line at apex of third abdominal segment. Armature of ventral abdominal segments confined to posterior margins, that of third and fourth segments consisting of 2 thorns, that of remaining segments of 4; laterad of the thorns on each segment are 2 slender bristles; apical segment much elongated (Pl. XXVIII, Fig. 8).

The foregoing description was made from the pupal exuvium of a female that was reared from a larva found by the writer under a log at White Heath, Ill., in March, 1916 (Acc. No. 46302).

Owing to the great uncertainty in identifying species of this genus from descriptions, the above name should be regarded as a tentative one.

Tipula bicornis Forbes

Tipula bicornis Forbes, 16th Rep. State Ent. Ill., p. 78. (1888)

This species was originally described by Dr. Forbes, as above

cited, the description of the imago being given on page 80. The species stands in the Loew collection at Cambridge, Mass., under the name *bicornis* Loew, but never was described by Loew.

Mr. Hart, in his "Entomology of the Illinois River and Adjacent Waters" unfortunately entered in his key the larva of *cunctans* as that of *bicornis.*

The larva of *bicornis* is almost inseparable by superficial characters from that of *Pachyrrhina ferruginea,* but possibly with better and more material than I have, such separation may be feasible. In examples which I have dissected I find that the labial plate and hypopharynx furnish characters that appear to be of specific value. These differences are shown in Figures 12 and 13, and 14 and 15, Plate XXXII.

The pupae of the two species are also very similar in structure, and I find in the shape of the apical segment of the females the only appreciable distinction. This difference is illustrated by Figures 5 and 7, Plate XXVIII. The apical segment of the male pupa may provide characters for the separation of this sex also; I have no male pupa of *bicornis* for examination.

The species is very widely distributed in this state, and is sometimes destructive to pastures, the larvae feeding on the roots of the grasses.

Pachyrrhina ferruginea Fabricius

Tipula ferruginea Fabricius, Sept. Antl., Species 28. (1805)

The larva (Pl. XXVIII, Fig. 4) of this species bears a striking resemblance to *T. bicornis* and is found in the same situations. I have no well-preserved specimens of authenticated *bicornis* for comparison of the external characters with those of *ferruginea.* The frontal plate is as in Figure 10, Plate XXXI, and dissection of the head shows the distinctions mentioned under *bicornis* (see Pl. XXXII, Figs. 14, 15). Apical abdominal segment as in Figure 3, Plate XXX.

The pupa is also very similar to that of *bicornis,* the only characters that appear to be useful in their separation being found in the apical abdominal segment–as stated in key. (See Pl. XXVIII, Figs. 5, 10, 12.)

The species is common and widely distributed in Illinois.

Principal Papers on North American Tipulidae

Hart, C. A.
'95. On the entomology of the Illinois River and adjacent waters. Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI.

Needham, J. G.
'07. Report of the entomologic field station conducted at Old Forge, N. Y., in the summer of 1905. Bull. N. Y. State Mus., No. 124:199–248.

Needham, J. G., and Betten, C.
'01. Aquatic insects in the Adirondacks. Bull. 47, N. Y. State Mus.

Osten Sacken, C. R.
'69. The North American Tipulidae. Monographs of North American Diptera, Part 4. (A list of additions and corrections appears at end of Part 3, which was published after Part 4.)

Family *LIMNOBIIDAE*

This family is of much greater extent than Tipulidae and contains a much larger number of genera, none of which in their larval and pupal stages—judging from the data at hand—show the same uniformity that is found in the genera *Tipula* and *Pachyrrhina*. It is difficult to separate the larvae and pupae of the two families, but I believe that the following summary of characters will serve this purpose.

FAMILY CHARACTERS

Larva.—Head in all subfamilies but Trichocerinae, Hexatominae, and Eriopterinae very similar to that of Tipulidae except that the antennae are much more slender, and frequently they are shorter than the maxillary palpi. The labial plate is often divided longitudinally in the center, each part being furnished with distinct teeth, while in all Tipulidae known to me the labial plate is entire and subtriangular, with a single apical tooth and usually several laterals. In Hexatominae and some Eriopterinae that I have examined the labium is not chitinized, and posteriorly the head is composed of 4 or 6 slender chitinized rods connected by weakly chitinized membrane. In Trichocerinae the head is complete, and the prothoracic spiracles are present. The mandibles in the species with tipulid-like head are much more slender than in Tipulidae, and in the latter when the apical segment has no protuberances the mandibles are very stout and have but 2 teeth, both at apex. The apical segment in Limnobiidae is very differently constructed in the different genera, but as far as I have seen there are never 6 processes, which in Tipulidae is the almost invariable number.

Pupa.—The pupae of all genera of this family known to me may be readily separated from those of Tipulidae by the straight palpi, since those organs in Tipulidae have their apices recurved.

HABITS OF LARVAE

The larvae have more diversified food-habits and habitats than do those of Tipulidae. A summary of these is given under the different genera dealt with in the text.

HABITS OF IMAGINES

The food of the imagines, when any is taken, usually consists of nectar.

Keys to Subfamilies

LARVAE

1. Thorax and abdomen with numerous long fleshy appendages...... ....Cylindrotominae (p. 210).
— Thorax and abdomen without long fleshy appendages...........2
2. Labium not chitinized; mandibles long and sickle-shaped, toothed only on basal half; maxillae with a very long membranous lobe at anterior lateral angle; apical segment with 4 processes, which are fringed with long hairs; penultimate segment in preserved larvae much distended..................Hexatominae (p. 232).
— Labium heavily chitinized except in Eriopterinae; mandibles stout, toothed on apical half; and otherwise not as above............3
3. Apical abdominal segment terminating in a pair of long tail-like appendages, the spiracles at their bases, above; labial plate divided in center..............................Pediciinae (p. 216).
— Apical abdominal segment terminating in 4 or 5 short protuberances, or at least not with 2 long terminal appendages.........4
4. Apical abdominal segment with 5 short terminal protuberances, the central one on upper margin about as large as the others; body usually pubescent or roughened; head posteriorly consisting of 6 slender rods........................Eriopterinae (p. 227).
— Apical abdominal segment with 4 terminal protuberances or without any, or if there are 5 the central one on upper margin is much smaller than the others and the head is not as above...........5
5. Head complete; prothoracic spiracles present.................... ....Trichocerinae (p. 234).
— Head incomplete posteriorly; prothoracic spiracles absent........6
6. Body green, with dense groups of fuscous hairs on dorsum of segments, which give it the appearance of being marked with black ....Limnobiinae, pt. (p. 212).
— Body yellowish, whitish, or brownish, without distinct groups of hairs as above.......................................7
7. Segments broader than long, lateral margins of prothorax with 1 strong hair, those of the other segments with 2 such hairs....... ....Rhamphidiinae (p. 226).

— Segments at least as long as broad, lateral margins without strong hairs...8

8. Body covered with short decumbent hairs, or, if bare, without narrow stripe-like locomotor areas; apical segment with 4 or 5 processes............................LIMNOPHILINAE (p. 220).

— Body without decumbent hairs; locomotor organs consisting of narrow transverse strips on dorsum and venter which are slightly leathery and armed with short spinules...LIMNOBIINAE, pt. (p. 212).

PUPAE

1. Thoracic respiratory organs very short and stout, not more than twice as long as their greatest breadth; armature of abdominal segments weak, the same on dorsum and venter, consisting of a single narrow, chitinized or setigerous, band.................2

— Thoracic respiratory organs very much elongated, usually more than 6 times as long as their greatest breadth or they are knobbed at apices; or abdominal armature usually strong, thorn-like or spinose, or not in the form of bands.........................3

2. Thoracic respiratory organs well separated basally..LIMNOBIINAE, (p. 212).

— Thoracic respiratory organs subcontiguous basally...RHAMPHIDIINAE (p. 226).

3. A pair of large leaf-like projections above bases of antennae...HEXATOMINAE (p. 232).

— No leaf-like projections above bases of antennae................4

4. Abdominal segments each with 2 or more very long thorn-like projections on posterior margin, which are in some species armed with small branches; rarely these projections are confined to apical 2 segments...................CYLINDROTOMINAE (p. 210).

— Abdominal segments each with small spines, or if rather large projections are present they are short and leaf-like, rather numerous, and unbranched..5

5. Thoracic respiratory organs stout, knobbed at apices...PEDICIINAE (p. 216).

— Thoracic respiratory organs slender, not knobbed at apices......6

6. Thoracic respiratory organs not slender and tube-like, flattened and but little elevated..................ERIOPTERINAE, pt. (p. 227).

— Thoracic respiratory organs long and usually tube-like, much elevated...7

7. Abdomen without dorsal or ventral armature; thoracic respiratory organs not longer than width of thorax, slender and tube-like....................................ERIOPTERINAE, pt. (p. 227).

— Abdomen either with distinct armature on apices of dorsal segments or on both dorsal and ventral ones and with the thoracic respira-

tory organs longer than width of thorax; or if the armature of abdomen is very weak the thoracic respiratory organs are not tube-like but acute apically...............LIMNOPHILINAE* (p. 220).

IMAGINES

1. Only one submarginal wing-cell present......................2
— Two submarginal wing-cells present..............................4
2. Antennae with 14 segments......................LIMNOBIINAE.
— Antennae with 16 segments......................................3
3. Tibial spurs present........................CYLINDROTOMINAE.
— Tibial spurs absent............................RHAMPHIDIINAE
4. Tibial spurs absent..............................ERIOPTERINAE.
— Tibial spurs present...5
5. Subcostal cross-vein proximad of base of second vein...PEDICIINAE.
— Subcostal cross-vein distad of base of second vein..............6
6. Antennae with 16 or more segments..............................7
— Antennae with at most 10 segments................HEXATOMINAE.
7. Seventh vein short, abruptly deflected towards anal angle........ ....TRICHOCERINAE.
— Seventh vein normal, not deflected towards anal angle............ ....LIMNOPHILINAE

Subfamily CYLINDROTOMINAE

This subfamily includes but four genera, each containing from one to four or five species, and because of the peculiar anatomical characters of the different stages it may yet be considered as entitled to separate family rank. I have treated the subfamily in this paper as belonging to Limnobiidae.

SUBFAMILY CHARACTERS

Larva.—Head similar to that of Tipulidae, the dorsal surface arcuate, heavily chitinized, and with 2 slits which usually extend proximad of the middle. Antennae slender, longer than maxillary palpi. Mandibles stout, with a strong apical tooth, and several smaller teeth along the lower margin. Labial plate similar to that of Tipulidae, the central tooth simple or bifid. Thoracic and abdominal segments with long fleshy spine-like processes which may be either simple or more or less furcate. Apical segment with 4 slender processes; spiracles rather small.

Pupa.—Head without projections; antennae curved over eyes. Thorax very short; respiratory organs long and slender; wings ex-

*I do not know what characters may serve to separate pupae of Limnophilinae and Trichocerinae.

tending to apex of second abdominal segment; legs, to or nearly to apex of third. Abdominal segments more or less distinctly subdivided by transverse incisions; dorsum of all segments or of the apical 2 with long thorn-like processes; lateral margins with short thorn-like protuberances.

Imago.—See key to subfamilies.

HABITS OF LARVAE

The larvae of this subfamily feed upon living plants, and are, as far as I know, the only species of Tipuloidea that have this food-habit. They also differ from all other Tipuloidea except Dicranomyia in being green. It is very difficult to detect them upon their food plants, which consist of living mosses, or, in the case of *Cylindrotoma*, of *Viola, Stellaria,* and *Anemone*. *Phalacrocera* feeds upon submerged aquatic mosses. The larvae are very sluggish.

HABITS OF IMAGINES

The flies are rather sluggish, and may be swept from plants on which the larvae have fed or from those along the margins of streams or ponds.

Keys to Genera

LARVAE

1. Thoracic and abdominal processes long and slender, the posterior submedian pair on each abdominal segment furcate near bases; aquatic or semiaquatic species (Pl. XXXIII, Fig. 1).......... ....*Phalacrocera*.
— Thoracic and abdominal processes short and leaf-like, not furcate near bases, at most with short protuberances..................2
2. Dorsal processes simple........................*Cylindrotoma*.
— Dorsal processes with short protuberances anteriorly............3
3. Some of the dorsal processes with 4 short protuberances on their anterior surface..................................*Triogma*.
— None of the dorsal processes with more than 2 protuberances on their anterior surface..............................*Liogma*.

PUPAE

1. Only the apical 2 abdominal segments with long, rather slender protuberances (Pl. XXXIII, Fig. 4).............*Phalacrocera*.
— All abdominal segments with long, slender protuberances..*Liogma*.

Subfamily LIMNOBIINAE

I have before me the larva of one species, and the pupal exuvia of two species, of *Limnobia,* and the larva and pupa of one species of *Dicranomyia.*

SUBFAMILY CHARACTERS

Larva.—Head well developed, moderately chitinized. Posterior dorsal slits extending proximad of middle; antennae elongate, base elevated, first joint more than twice as long as broad; maxillary palpi much shorter than antennae, 2-jointed; labial plate well developed, dentate along its anterior margin; mandibles stout, with one or two large apical teeth, and a series of smaller teeth along their lower margin on its apical half. Thorax and abdomen without pseudopods, the locomotor organs consisting of a narrow transverse strip of weak hairs or spinules on the dorsal and ventral surfaces of some or all of the segments; in *Dicranomyia* these locomotor spinules are little stronger than the others on dorsum. Apical segment without finger-like processes; the spiracles in terrestrial forms not in a pronounced depression but capable of being enclosed by the infolding of the apex of the segment; the spiracles in aquatic forms situated in a cleft, with hair-fringed margins, in apex; both terrestrial and aquatic forms with short protrusive blood-gills.

Pupa.—Head without protuberances. Thoracic respiratory organs very broad, their length not exceeding their greatest width; legs much longer than wings. Abdomen with locomotor organs similar to those of larva.

Imago.—See key to subfamilies.

HABITS OF LARVAE

The larvae of *Limnobia* are fungivorous and terrestrial; those of *Dicranomyia* feed on algae and are aquatic or semiaquatic. A glutinous tube is made by the larvae of both genera when nearly or quite mature, and in this pupation takes place.

HABITS OF IMAGINES

The species of *Limnobia* usually occur in dense woods where fungi are common; those of *Dicranomyia* occur near bodies of water. The species of *Geranomyia* frequent flowers, as do the adults of some of the other genera.

Keys to Genera

LARVAE

1. Apical abdominal segment appearing cleft, the margins of the cleavage fringed with hairs; body with close pubescence; apical ventral blood-gills slender, pointed....... *Dicranomyia simulans.*

— Apical abdominal segment rounded or slightly truncate, not cleft, and without hairs; body not pubescent; apical ventral blood-gills stout, rounded................................. *Limnobia.*

PUPAE

1. Thoracic respiratory organs broad, subquadrate, their apices truncate, the bases with a hook-like protuberance.................. .... *Dicranomyia simulans.*

— Thoracic respiratory organs rounded, ear-like, without any hook-like protuberances at base........................ *Limnobia.*

Dicranomyia simulans Walker

Limnobia simulans Walker, List of Diptera in British Museum Coll., Pt. I (1848), p. 45. Imago.

Dicranomyia simulans (Walker) Needham, 23d Rep. State Ent. N. Y., p. 214. (1907)

Larva.—Length, 11–13 mm. Green, with distinct fuscous marks on dorsum which are broken up by small round clear spots and irregular clear patches. A close examination discloses the fact that the fuscous areas are composed of closely placed spinose hairs, while the clear spots are either devoid of hairs or yellowish hairs are present.

Head large, similar in general appearance to that of *Limnobia;* antennae long, the shaft about 3 times as long as its greatest diameter; maxillary palpi short and inconspicuous; labium slightly convex in outline, central tooth much longer and stouter than the first lateral, second and third laterals as large as central. Thoracic and abdominal segments each with distinct anterior marginal fusiform area, these areas not armed with distinct spinules; incisions between dorsal segments of abdomen margined with blackish spinules which are appreciably, but not much, stronger than the hairs on the fuscous dorsal markings; apical segment with a cleft appearance, the aperture closing, mouth-like, with the lips vertical.

Pupa.—Length, 8–9 mm. More fuscous than the larva.

Thoracic respiratory organs as in Figure 5, Plate XXXIII, their structure separating them from any other genus known to me. My only specimen is in a fragmentary condition, which prevents me from

giving a detailed description.

Described from materials obtained by D. K. McMillan at Lake Forest, Ill., November 29, 1916.

The larva and pupa of this species were described by Needham from this same locality, where they are abundant among algae on the piers, just above and below the surface of the water.

Limnobia Meigen

GENERIC CHARACTERS

Larva.—Head broad, the exposed portion, except for the labrum, subquadrate; antennae of moderate length, 2-jointed; mandibles rather large. Body consisting of 12 segments; dorsal and ventral surfaces with some or all of the segments individually armed with a transverse band of setulae, those on ventral segments situated upon more or less raised transverse ridges or swellings; apical segment with 2 large, rounded spiracles, without well-defined tubercles, anal ventral blood-gills short, consisting of a pair on each side.

Pupa.—Head unarmed. Thoracic respiratory organs in the form of a large disc-like chitinized plate which is attached, ear-like, to anterior lateral angle of thorax; legs elongated, the hind pair covered almost to apex of basal tarsal joint by the wings, so that only 2 pairs are visible for this distance, apices of tarsi almost in a straight line; wings ending at apices of basal tarsal joints. Armature of abdominal segments similar to that of larva except that the apical segment is slightly chitinized and more or less tuberculate.

I can not describe the position of the legs in either of the species before me as only exuvia are available. The figure of *immatura* is made from a cast pupal skin, and details of the venter of the thorax are incomplete. The spiracles on the abdomen are not well defined, the normal chitinized margin of the openings, so evident in many groups, being absent. In the specimens before me there are, however, two spiracles with distinct chitinized rims on the dorsum of the eighth segment which are connected with stout tracheae. In the specimen of *immatura* the main tracheae are still visible and each is connected with the integument on the lateral margin of the segments. The apices of the lateral branches appear to connect, by means of a compact mass of thread-like branches, with the wall of the abdomen, and have no distinguishable external aperture. Without a larger amount of material for study I can not definitely state whether these lateral tracheae are functional or not.

HABITS OF LARVAE

The only species that I have reared was found feeding in fungi (*Agaricus* sp.). The species are recorded as fungivorous. Before pupation the larva forms a glutinous tube which is very compact, and in this the pupa is enclosed. The pupa of *immatura* was found under a bush in woods near Urbana, the larva having very probably fed upon some fungus there.

HABITS OF IMAGINES

The imagines of many species of this genus are found commonly in woods, flying among the low herbage, and are also frequently taken feeding on nectar of various plants.

LIMNOBIA TRIOCELLATA Osten Sacken

Limnobia triocellata Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 216.

Larva (Pl. XXXIII, Fig. 13).—Length, 18–20 mm. White, semitransparent (alcoholic specimens). Dorsum of head with a large blackish patch on each side. Head as in Figures 16 and 17; mandibles as in Figure 6; antennae of moderate length, distinctly 2-jointed. Thoracic segments 2 and 3 each with a large number of transverse series of minute spinules on anterior fifth of dorsal surface; first segment with a few microscopic hairs rather longer than the spinules on segments 1 and 2; ventral surface of the three segments with very similar armature, that on 2 and 3 the more compact, rather longer, and with the areas occupied by it slightly elevated. Abdominal segments 1–7 each with a narrow transverse stripe of short black spinules on posterior margin, the stripes tapering to a point on each side and not reaching lateral margin except in the case of the one on segment 7, which is broad and connects with a similar band or stripe on ventral surface; anterior margins of all segments of venter with a transverse swelling which is armed with stiff black spinules similar to but rather longer than those on dorsal surface, these spinules and those of the dorsal series, without magnification, giving the larva the appearance of having 7 narrow black dorsal stripes and 10 broader ventral ones; apical segment with the large rounded spiracles situated in a slight cavity, the margins of which are slightly irregular but not furnished with well-defined tubercles, the spiracles being capable of entire enclosure by the retraction of the central cavity and the infolding of the margin; apical ventral surface with a pair of short, rounded, retractile blood-gills (Fig. 10).

Pupa.—Length, 12–15 mm. Pale yellowish testaceous; head, thorax, and base and apex of abdomen pale brown, slightly shining. Head without armature, front view as in Figure 2, Plate XXXIV. Thoracic respiratory organs reddish brown, similar to those of *immatura*; wings and legs as described for this genus. Abdominal segments 3–8 each with a conspicuous transverse band of short setulae on anterior margins of both dorsal and ventral surfaces, the bands not connected on lateral margins; the 2 basal ventral bands widely interrupted below legs, the apical one also interrupted, the others complete; abdomen without distinct spiracles except a pair on dorsum at base of apical segment which are connected with stout tracheae; apical segment as in Figures 3 and 4, Plate XXXIV, basal 3 segments and the penultimate dorsally slightly brownish yellow, probably owing to the presence of chitin; apical segment almost entirely brownish yellow.

Described from larvae and from pupal exuvia of specimens obtained by the writer from a species of fungus (*Agaricus*) in the forestry of the University of Illinois, at Urbana, in September, 1915.

Limnobia immatura Osten Sacken

Limnobia immatura Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 215.

Pupa (Pl. XXXIII, Fig. 11).—Length, 20 mm. Color as in preceding species. Differs from it in size, in the structure of the respiratory organs (Pl. XXXIII, Fig. 14), and in that the median interruption of the setulose band is on the seventh ventral segment. There is also a slight but distinct difference in the structure of the front of the head, as shown in Figures 1 and 2 of Plate XXXIV; but this may be due to the different sex of the specimens—which in large measure accounts for a difference in the structure of the apical abdominal segments of the specimens (Pl. XXXIII, Figs. 11, 12).

Described from pupal exuvium of a female. The pupa was found near a bush in Cottonwood Grove, about four miles east of Urbana, Ill., March 23, 1911, and emerged four days later (C. C. Dillon).

Subfamily PEDICIINAE

With the exception of the larvae of two species, I have no materials representing this subfamily, and depend upon the published description of *Dicranota* by Miall and of *Pedicia* by Beling for characters of the pupae.

SUBFAMILY CHARACTERS

Larva.—Head well developed, the dorsum chitinized and with 2 elongate posterior excisions; labium well developed, in some genera (*Pedicia* and *Dicranota*) in the form of 2 plates; mandibles stout, their inner lower margin toothed. Some of the abdominal segments with conspicuous locomotor organs, either in the form of paired pseudopods or elevated transverse areas. Apical segment with 2 long terminal processes. Spiracles situated on dorsum at base of terminal processes.

Pupa.—Distinguishable from allied forms by the knobbed respiratory organs. The ventral segments of the species described by Miall each have a pair of tubercles on the disc, but Beling's description of the pupa of *Pedicia rivosa* makes no mention of such tubercles.

Imago.—See key to subfamilies.

HABITS OF LARVAE

The larvae are aquatic, feeding upon algae and small Crustacea of various kinds, or upon aquatic worms.

HABITS OF IMAGINES

The imagines are of a rather sluggish habit, and may be swept from vegetation in the vicinity of streams. Their food-habits are the same as those of Eriopterinae.

Keys to Genera

LARVAE

1. Very large species, 35–45 mm. in length; paired pseudopods confined to segments 8–11; anal ventral blood-gills very long, about equal in length to the apical processes................*Pedicia.*

— Smaller species, not exceeding 25 mm. in length................2

2. Ventral surface of apical abdominal segment with 4 slender protrusive blood-gills; spiracles conspicuous, situated on rather large elevations..*Dicranota.*

— Ventral surface of apical abdominal segment without, or with very small, slender protrusive blood-gills; spiracles very small, situated upon small elevations........................*Rhaphidolabis.*

PUPAE

1. Ventral abdominal segments without wart-like elevations; large species, more than 30 mm. in length..................*Pedicia.*

— Ventral abdominal segments each with a pair of wart-like elevations; small species, not more than 20 mm. in length. .*Dicranota.*

Pedicia Latreille

I have not seen the immature stages of this genus, my information regarding them having been obtained from published descriptions. These justify the following generalizations for the larvae and pupae.

GENERIC CHARACTERS

Larva.—Head narrow, similar in general structure to that of *Dicranota* (Pl. XXXIV, Fig. 9), the dorsal surface compact, arcuate; mandibles slender, the apical tooth long and pointed, inner lower margin with several smaller teeth; maxillary palpi longer and stouter than the antennae. Body with weak isolated hairs, or bare, the segments distinct; ventral surface of segments 8–11 each with a pair of transverse pseudopods, the apices of which are not armed with spinules; apical segment with 2 long terminal processes, at the base of which, on the dorsal surface of the apical segment, are the spiracles on slight elevations; ventral anal blood-gills, when fully extended, as long as terminal processes.

Pupa.—Differs from that of *Dicranota* in the absence of ventral protuberances.

HABITS OF LARVAE

The larvae are aquatic and usually occur in still water—in springs or wells. They feed upon algae, diatoms, and small crustaceans.

HABITS OF IMAGINES

The flies of this genus are very large, and the wing-markings and conspicuously marked abdomen of the common species render their detection in nature very easy. Their flight is slow and heavy, and they seldom rise much above the level of the rank vegetation in the marshy or wet situations in which they normally occur.

Pedicia albivitta Walker

Pedicia albivitta Walker, List of Diptera in British Museum Coll., Pt. I (1848), p. 37. Imago.

Tipulid sp.? Needham, Bull. 68 N. Y. State Mus., p. 285. (1903)

Needham, in the bulletin cited above, described and figured the larva and pupa of this species.

The species is represented in our collection by an imago from New York State.

Dicranota Zetterstedt

I have the larva of one species of this genus, which is described herein. I have used Miall's description of a European species as an index to the pupal characters of the genus, as this stage is unknown to me.

The characters for the separation of the larvae of this genus from those of *Pedicia* and *Rhaphidolabis* are summarized in the synoptic key.

Dicranota sp. ?

Larva (Pl. XXXIV, Fig. 7).—Length, 10 mm. Whitish yellow. Head black.

Head long and narrow, posterior portion in the form of a compact arcuate capsule, the sutures poorly defined except in middle and on posterior margin (Pl. XXXIV, Fig. 9). Antennae long and slender (Fig. 6); maxillary palpi about the same length as antennae but much stouter (Fig. 5), the sensory area very distinct; mandibles long and slender, the apical tooth very acute, inner lower margin with 2–3 smaller teeth; labium divided centrally, each side with 3 sharp teeth, the median one of each trio smaller than the others. Segments of body well differentiated, clothed with close decumbent pile and without distinguishable bristles; 5 pairs of pseudopods on ventral surfaces of apical 6 segments exclusive of the last one, their apices armed with spines; spiracles situated on a pair of short processes at base of the prolonged apical protuberances; ventral blood-gills short, 4 in number.

Described from a specimen taken by Dr. S. A. Forbes among weeds and stones in a stream on Bottlers Ranch, Yellowstone National Park, September 14, 1891.

Dicranota bimaculata Schummel

Dicranota bimaculata Schummel, Miall, Trans. Ent. Soc. London, 1893, pp. 235–253. Larva and pupa.

Prof. L. C. Miall published a detailed account of the life history and anatomy of this species in the paper cited above. In general the larva agrees with the one just described, the differences being found in the structure of the head. I have, however, to rely upon Miall's description and figures of the pupa for details of that stage.

Pupa.—Thoracic respiratory organs elevated, rather stout, their

apices with truncated knobs. The abdomen is furnished upon the middle of the dorsum of the second and sixth segments with a roughened plate clothed with short coarse spines, and the intervening segments each have 2 such plates, one before, and the other behind, the middle. Ventral segments 3–7 each with a pair of widely separated papilliform tubercles in a transverse line at middle. Apical segment elongate, without spines.

This species is aquatic in the larval stage, but pupates in moist earth along the banks of the streams in which the larvae occur. The larvae feed upon the worm *Tubifex rivulorum.*

Rhaphidolabis Osten Sacken

I have but one larva that I regard as belonging to this genus. It very closely resembles that of *Dicranota,* differing in being slightly more slender; in having the pseudopods armed with a more regularly curved semicircle of apical spinules, the spiracles much smaller and less elevated, the apical processes longer; and in the apparent absence of the ventral blood-gills.

This specimen was taken by Dr. S. A. Forbes among vegetable refuse in Blacktail Deer Creek, Yellowstone National Park, August 28, 1890.

The larva of *R. tenuipes* has been figured by Needham*.

The species are aquatic in the larval stage, occurring in streams.

Subfamily LIMNOPHILINAE

I have before me representatives of but one genus of this subfamily, and have found descriptions of but two others of the ten genera which it contains.

SUBFAMILY CHARACTERS

Larva.—Head well chitinized, much as in *Tipula,* the principal differences being the much longer maxillary palpi, which exceed the antennae in length, and the less robust mandibles. The labium also shows a departure from the tipulid type and is produced into a rather acute central point anteriorly, but the genera in which the structure of this plate is known to me differ materially, and a generalization is not justifiable, more particularly as both forms are found in other subfamilies. Apical abdominal segment with 4 or 5 protuberances on

*Twenty-third Rep. N. Y. State Ent., p. 201. (1908)

margin of stigmatal field; ventral blood-gills present or absent. Body with short silky pubescence or bare; bristles absent.

Pupa.—Head without chitinized protuberances; palpi straight. Thoracic respiratory organs long and slender, sometimes pointed apically. Legs extending much beyond apices of wings. Abdomen with weak armature, consisting of 1–3 transverse bands of weak spines and some longer slender hairs, or of only weak hairs, the segments with the usual transverse incisions, giving them a divided appearance.

HABITS OF LARVAE

The larvae of the genus *Ula* are fungivorous, living usually in Polypori; those of *Limnophila* and *Epiphragma* are aquatic or semiaquatic, feeding upon algae and decaying vegetable matter, the last-named genus occuring in dead stems of plants.

HABITS OF IMAGINES

Most species of the subfamily fly in the evening, and they are not uncommonly attracted to lights.

Keys to Genera

LARVAE

1. Apical segment with 2 long and 2 short processes which are fringed with very long hairs; labium divided centrally...... *Limnophila.*
— Apical segment with 4 or 5 short, pointed processes which are inconspicuously or not at all fringed........................ 2
2. Apical segment with 4 processes.................. *Epiphragma.*
— Apical segment with 5 processes........................ *Ula.*

PUPAE

1. Thoracic respiratory organs rather short, swollen at base and acute at apices.................................... *Epiphragma.*
— Thoracic respiratory organs long and slender, of nearly uniform thickness throughout their entire length, not acute at apices.... 2
2. A number of hairs on frons between antennae........ *Limnophila.*
— No hairs on frons between antennae...................... *Ula.*

Limnophila Macquart

GENERIC CHARACTERS

Larva.—Head moderately chitinized, the ventral, median posterior opening large. Antennae short and slender, with a long apical hair,

or 2 such hairs; frontal plates large; maxillary palpi longer and much stouter than antennae; labial plate divided in center, the lateral pieces digitate. Apical segment with 4 long processes which are furnished with long fringes; pseudopods absent.

This description applies to aquatic forms only; the terrestrial forms are unknown to me.

Pupa.—Palpi straight; antennae extending to or beyond bases of wings. Thoracic respiratory organs long and slender, least chitinized at apices; legs extending beyond apices of wings, disposed side by side. Abdomen with a number of transverse setigerous ridges on each dorsal and ventral segment, or with distinct tubercles in similar series.

HABITS OF LARVAE

The only larvae known to me are aquatic. The very long fine hairs on the apical abdominal segment take a very firm hold of the surface of the water when the processes which they border are expanded, and it requires considerable effort on the part of the larva to detach them in order to descend. Hart has stated that detachment is accomplished by throwing the cephalic extremity round in such a way that the thoracic segments pass over the apex of the abdomen, and thus their hold on the surface of the water is released. I have frequently seen the larvae do this, but only in water too deep for them to get hold of anything in the bottom. A considerable quantity of air is carried down within the confines of the fringes of the apical processes when the larva descends below the surface of the water, and when this is exhausted the larva ascends for a fresh supply. In cases where the specimens are able to feed without entirely submerging the body, the apical segment is expanded on the surface of the water and forms a conspicuous crater-like cavity within which are visible the eye-like anal spiracles.

The food consists of decaying vegetable matter and algae.

I have found the larvae common at Muncie and White Heath, Ill., but only along the margins or in the muddy banks of streams.

I have reared two species, but the larva of only one of them has been associated with the pupa and imago.

LIMNOPHILA LUTEIPENNIS Osten Sacken

Limnophila luteipennis Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 236.

The larva and pupa are described by Hart in the paper frequently cited herein*, and the following details should be accepted as supplementary to that description.

---

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 202–204.

Larva (Pl. XXIX, Fig. 4).—Length, 15–18 mm. Yellowish testaceous or slightly olivaceous.

Head dorsally as in Figure 7, Plate XXXIII, the antennae short and slender (Pl. XXXIII, Fig. 2); mandibles as in Figure 15, Plate XXXIII, being quite different in form from those of Hexatominae and more resembling those of *Limnobia*; labium (Pl. XXXIII, Fig. 3) divided in center, each half with 7 teeth; maxillary palpi with 3 joints. Body with rather conspicuous surface hairs which are situated on slight transverse ridges; apical segment (Pl. XXX, Fig. 1) with 2 short upper and 2 long lower processes which are fringed with very long hairs; ventral blood-gills 4 in number.

Pupa (Pl. XXIX, Fig. 5).—Length, 10–13 mm. Color as in the larva.

Thoracic respiratory organs (Pl. XXXIII, Fig. 18) slightly longer than wings, their apices split; legs ending in a straight transverse line at apex of second abdominal segment; each dorsal abdominal segment except basal with 5 transverse series of hair-like bristles set on small chitinized elevations which form slight ridges, the posterior pair much more widely separated than the others. Ventral segments with 6 such transverse series arranged as on dorsal segments. Apical segment of female composed of 2 pairs of elongate processes which form an acute tip, the lower pair two thirds as long as the upper.

This species is probably present in every stream and river in the state, as I have found it wherever I have collected in March and April.

Limnophila tenuipes Say

Limnophila tenuipes Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 21. (1823)

I have obtained only the pupa of this species. It resembles *luteipennis* in general shape and in the arrangement of the cephalic and thoracic appendages, but in the armature of the abdomen there is a notable difference.

Pupa.—Length (exclusive of the respiratory organs), 10–15 mm. Blackish brown.

Thoracic respiratory organs rather more slender than in *luteipennis*. Abdominal segments, exclusive of the basal dorsal, those covered by the legs, and the apical one, each with 3 transverse pairs of widely separated protuberances, the distance between those of each series less than the distance from either to the lateral margins; distance between the most posteriorly placed pair and posterior margin of segment greater than the distance between the pairs; posterior margin with

4–6 smaller protuberances which, like the others, are armed at apices with 1–2 weak hairs; lateral margins with a tubercle at a point corresponding to the situation of the dorsal and ventral transverse series; apical segment of male and female as in Figures 8 and 9, Plate XXXIII.

I collected a large number of pupae of both sexes of this species on the banks of the Sangamon River at White Heath, Ill., May 28, 1916. I found that by taking mud from the bank and disintegrating it in the water I could readily obtain the pupae as they floated at the surface. The species is common in Illinois, and probably occurs in most of its streams. The pupa was described by Mr. Hart as *Limnophila* species (*a*) in his paper previously referred to.

Epiphragma Osten Sacken

I have not seen the early stages of this genus, but those of *fascipennis* have been described by Needham, as indicated in the synonymy under the species name.

GENERIC CHARACTERS

Larva.—Details of the cephalic structure are lacking in Needham's description, and as I have no means of ascertaining these, only the superficial characters can be indicated. Body cylindrical, without surface hairs or bristles; ventral pseudopods represented by fusiform ventral areas; apical abdominal segment with 4 short marginal processes and 4 slender protrusive ventral blood-gills.

Pupa.—Thoracic respiratory organs much shorter than in *Limnophila* and *Ula*, and more horn-like than tube-like, their apices incurved and acute. Legs extending beyond apices of wings the length of 2 abdominal segments, terminating in an almost straight transverse line. Abdomen without thorn-like armature, only bristly hairs present at apices of segments.

Epiphragma fascipennis Say

Limnobia fascipennis Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 19. Imago. (1823)

Epiphragma pavonia Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 239. Imago.

Epiphragma fascipennis Say, Osten Sacken, Mon. N. Am. Dipt., Vol. 4, p. 194. Imago. (1869)

Epiphragma fascipennis Say, Needham, Bull. 68, N. Y. State Mus., p. 281. Larva and pupa. (1903)

Larva (Pl. XXXV, Fig. 2).—Length, 19 mm. White, or faintly tinged with yellowish.

Head large for the family. (No structural description given by Needham.) On the ventral side of the three thoracic segments is a pair of minute brownish points. Ventral side of segments 2–7 each with a single median proleg—a mere soft, white, transversely placed ridge, without hooks or claws. The abdomen is without other tubercles, spines, or hairs. Spiracles large, widely separated. Spiracular disc with 4 thick marginal processes, the upper pair blunt apically, fringed with hairs, and separated by the full width of disc, the lower pair a little more pointed and a little closer together (Pl. XXXV, Fig. 3). Anal blood-gills slender, 4 in number.

Pupa (Pl. XXXV, Fig. 9).—Length, 12 mm. Ventral view and general appearance as in figure. Apical carina on each abdominal segment fringed with short stiff hairs, those on the ventral side of eighth segment more comb-like, and interrupted on the median line in female.

The foregoing descriptions are abridged from Needham's paper, and the accompanying figures are copied from the same author.

The materials used by Needham in making his descriptions were obtained at Lake Forest, Ill., where the larvae were found boring in the dead stems of buttonbush and willow lying on the mud at the borders of shallow pools.

The species is represented in our Laboratory collection by imagines from Algonquin and Urbana, Ill., and from Philadelphia, Pa., all being taken in June.

Ula Haliday

GENERIC CHARACTERS

Larva.—Body cylindrical, without hairs; pseudopods faintly indicated in the form of slight transverse ventral fusiform areas on apical portion of abdomen. Labium entire; maxillary palpi longer than the rather stout antennae. Apical abdominal segment with 5 processes on margin of spiracular disc.

Pupa.—General appearance similar to that of *Limnophila*, but the armature of the abdomen differs noticeably in being confined to the posterior margins of the median dorsal segments.

Ula elegans Osten Sacken

Ula elegans Osten Sacken, Mon. N. Am. Dipt., Vol. 4, p. 276. Imago. (1869)
Ula elegans Osten Sacken, Alexander, Pomona Jour. Ent. and Zool., Vol. 7, pp. 1–8. (1915)

Larva.—Length, 8.5–11.9 mm. White, the head brownish black, shining.

Antennae short and stout, armed at apices with 2 short processes; labium with a small central tooth, the first lateral on each side distinctly larger and extending anteriorly beyond the apex of the central one, sides of plate sloping abruptly backward, armed with 3 teeth; mandibles stout, their inner margin with 2 teeth in addition to the apical one. Apical abdominal segment with the dorso-central process small, the lateral much longer and slightly more pointed than the latero-ventrals, all fringed with marginal short hairs and each with conspicuous black mark on the posterior surface; anal blood-gills absent.

Pupa.—Head without anterior protuberances. Palpi curved slightly forward at their apices. Thoracic respiratory organs long and slender, dark basally, pale apically; legs extending to middle of fourth segment beyond apices of wings. Dorsal abdominal segments 2–6 each with a noticeable transverse subchitinized band of a shagreened texture; the disc of segments with small setigerous punctures.

The above descriptions are abridged from Alexander's, reference to which is given under species name. Alexander's material was obtained at Ithaca, N. Y. The larvae feed in fungi, *elegans* being taken in a species of *Fomes* (*Polyporus*) growing on a tree-stump. The imagines emerged in September and October.

The species occurs throughout the Atlantic states and is recorded from Wisconsin, so that it probably occurs in Illinois though we have no record of it.

Subfamily RHAMPHIDIINAE

The only information I have regarding the larval and pupal stages of this subfamily is that contained in the description of the European species *Elliptera omissa.* The larvae of *Rhamphidia longirostris* has been found by Gercke, but he did not describe it.

The characters of the larva and pupa of *Elliptera* as indicated by Mik are given below. One species of this genus, *clausa* Osten Sacken, occurs in North America.

Elliptera omissa Egger

Elliptera omissa Egger, Verh. d. zool.-bot. Ges., Vol. 13, p. 1108. Imago. (1863)
Elliptera omissa Egger, Mik, Wiener Ent. Zeit., 1886, p. 337. Larva and pupa.

Larva.—Length, 7 mm., breadth, 1.5 mm. More robust than most members of the family, the segments distinctly broader than long.

Head heavily chitinized, dorsum with the usual 2 longitudinal dorsal excisions and a smaller median posterior one. Antennae short and slender. Labium heavily chitinized, triangular in outline, margin dentate. Mandibles strong, curved, their inner margin dentate. Body slightly flattened dorso-ventrally, the segments distinct, with decumbent pale pile, and having long bristle-like hairs on lateral margins of each segment, 1 on the prothorax and 2 on each of the other segments. Abdominal segments 2–8 each with a narrow transverse fusiform stripe on ventral and dorsal surfaces near the anterior margins which is armed with short spinules. Apical segment tapered, cleft, the margins of the cleavage with 2 upper and 2 lower processes, each pair margined with fine hairs.

Pupa.—Length, 6.5 mm. Yellowish brown, the abdomen greenish white.

Thoracic respiratory organs about as long as diameter of thorax, very stout, their bases almost contiguous, tapering from base to apex, and more or less resembling the pincers of a crab. Abdomen armed as in larva except that the lateral hairs are wanting. Legs extending to base of antepenultimate abdominal segment. Apical segment prolonged slightly in both sexes, that of the female a trifle the longer, a few small processes present in both sexes at base.

This genus agrees well in the larval and pupal stages with the corresponding stages of *Dicranomyia,* the distinctions between them being less marked than is the case with allied genera of some other subfamilies.

Subfamily ERIOPTERINAE

Helobia and *Gnophomyia* are the only genera of this subfamily of which identified larvae and pupae are before me. I have, however, an unidentified larva that quite obviously belongs here. There is a great similarity in these larvae, but judging from the available descriptions of European species of other genera a great difference exists between the forms I have and those of other European genera. The description of the larva of *Trimicra* agrees with the characters generally attributed to larvae of Pediciinae—a fact that to my mind throws considerable doubt upon the correctness of the present subfamily-grouping, which is based upon characters of the imagines. I have no intention of rearranging the genera in this or any other subfamily upon the basis of characters deduced from printed descriptions, and accordingly leave the subfamilies practically as in Williston's "Manual", but consider it essential to indicate the probability of errors in the arrangement.

I do not include in the following synopsis of characters, nor in my keys, genera which I do not possess, though they may have been described by other authors; but notes upon *Erioptera* are given in the text owing to the existence of a previous record of the occurrence of a larva of that genus in Illinois.

SUBFAMILY CHARACTERS

Larva.—Slender, cylindrical, tapering slightly towards both extremities, the body covered with dense decumbent pile. Head small, poorly chitinized; labium unchitinized; the main portion of head consisting of slender chitinized rods, 4 or 6 in number.

Pupa.—Head as in Limnobiinae, without projections; palpi straight; directed laterad. Thoracic respiratory organs short, or if of considerable length, still noticeably shorter than those of Limnophilinae known to me, and of a uniform strength throughout; legs longer than wings. Abdomen with weak armature, which is not in the form of transverse bands or series of spinules; spiracles distinct.

Imago.—See key to subfamilies.

Keys to Genera

LARVAE

1. Body with almost indistinguishable surface hairs; ventral surface of abdominal segments without distinct transverse pseudopod-like swellings.......................... *Helobia punctipennis.*

— Body covered with rather long and very dense decumbent hairs which give the larva a silky appearance; ventral surface of abdominal segments with distinct transverse pseudopod-like swellings.............................. *Gnophomyia tristissima.*

PUPAE

1. Thoracic respiratory organs pressed close against surface of thorax; legs extending very slightly beyond apices of wings (Pl. XXVIII, Fig. 15)........................... *Gnophomyia tristissima.*

— Thoracic respiratory organs erect, tube-like, not pressed against surface of thorax; legs extending very far beyond apices of wings.. .... *Helobia punctipennis.*

Helobia St. Fargeau

GENERIC CHARACTERS

Larva.—Cylindrical, slightly tapering towards the extremities. Head small, entirely retractile, caudad of mandibles consisting of 6

chitinized rods with weakly chitinized connecting membrane. Body with very indistinct surface pilosity. First thoracic segment with an indistinct transverse median division. Abdominal segments 2–7 with a median transverse constriction or division. Apical segment with 5 stout protuberances.

Pupa.—Differs from the pupa of *Gnophomyia* in the structure of the thoracic respiratory organs, which are slender and elongate. The legs also are more elongate than in *Gnophomyia.*

HABITS OF LARVAE

The larvae are found in mud and sand along the margins of streams. They burrow in the wet sand and are able to live under water like the larvae of *Limnophila,* though they are less commonly found there.

HABITS OF IMAGINES

The imagines are very common throughout Illinois and usually fly in the late afternoon. They are readily attracted to lights at night. They may feed upon nectar, but the mouth parts are poorly developed.

Our species occurs also in Europe.

HELOBIA PUNCTIPENNIS Meigen

Limnobia punctipennis Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 1, p. 17. (1818)

Larva (Pl. XXIX, Fig. 6).—Length, 8–10 mm. Pale yellowish testaceous.

Head (Pl. XXXIV, Fig. 18) poorly chitinized, the posterior portion consisting of slender blackish rods, the intervening spaces filled with weakly chitinized membrane; antennae short, 2-jointed, the apical joint very short; maxillary palpi longer than antennae and much stouter; mandibles stout, their lower margin toothed (Pl. XXXIV, Fig. 11); labium apparently not chitinized, indistinguishable in my specimens. Body covered with short decumbent pile, which is less conspicuous than in the other larvae of this subfamily. Segments with the usual transverse linear incision on dorsum; apical segment as in Figure 17, Plate XXXIV.

Pupa (Pl. XXIX, Fig. 7).—Length, 7–9 mm. Color as in the larva.

Thoracic respiratory organs tube-like, from 6 to 8 times as long as their greatest diameter; prothorax flattened, declivitous, with an elongate, rather broad foveate mark on each side of dorsum; anterior margin of mesothorax with a slight ridge-like swelling, upon which are

numerous small spinules and, laterally, 2 or more small tubercles; legs extending well beyond apices of wings, apices of fore tarsi extending beyond apices of mid pair, apices of hind pair extending beyond apices of fore pair. Abdomen without noticeable armature; apical segment of female elongate, the upper processes longer than the lower, that of male obtuse, with 7 slight protuberances, 3 in a transverse line before apex on dorsum and 4 at apex—2 above and 2 below, the latter acute.

The material used in drawing up the foregoing descriptions is that which Mr. Hart had when he wrote his paper on Illinois River species. He did not describe the early stages, referring merely to Beling's description of them which appeared in a European publication.

Gnophomyia Osten Sacken

GENERIC CHARACTERS

Larva.—Head rather small, wholly retractile, posteriorly composed of slender chitinized rods. Body covered with dense silky hairs. General form similar to that of *Helobia,* the principal differences being the much less conspicuous hairs on the surface of the latter, the absence of distinct ventral locomotor organs, and the longer radiating processes of the apical segment.

Pupa.—The structure of the thoracic respiratory organs sufficiently distinguishes this genus from *Helobia.*

HABITS OF LARVAE

The larvae live in mud, especially along the banks of streams.

HABITS OF IMAGINES

The flies are usually found in damp situations, especially in grass along the margins of ponds or streams. They feed on nectar or liquids.

Gnophomyia tristissima Osten Sacken

Gnophomyia tristissima Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 224.

Larva.—Length, 9–11 mm. Slender, slightly tapering towards both extremities, more decidedly towards the cephalic. Body yellowish testaceous, covered with dense decumbent pile.

Head more compact than that of *Helobia*, the lateral rods stouter (Pl. XXXIV, Fig. 10); antennae very small; maxillae large, pro-

duced beyond the apex of the narrow labrum, the palpi stout; labium not chitinized; mandibles slender, with a long sharp apical tooth and about 3 poorly defined teeth along the lower lateral margin. Locomotor organs consisting of rather broad fusiform areas on anterior portion of abdominal segments except basal and apical; hairs along margins of segmental incisions more distinct than elsewhere because of their being slightly curved upward; apical segment with 5 processes, their structure and markings as in Figure 16, Plate XXXIV; anal ventral blood-gills in the form of 4 short rounded protuberances.

Pupa (Pl. XXVIII, Fig. 15).—Length, 8–10 mm. Color as in larva.

Thoracic respiratory organs very little elevated, in the form of longitudinal ridges very similar to those of some Tabanidae. Prothorax not so decidedly declivitous as in *Helobia.* A very long hair on each side of thorax just above and slightly in front of base of wing; front view of thorax and appendages as in Figure 15, Plate XXVIII. Lateral margins of abdomen with long hairs situated upon slight elevations, as shown in figure last mentioned; spiracles larger than in most genera in the family, 6 pairs distinct; apical segments of male and female as in Figures 16, 17, and 18, Plate XXVIII.

The foregoing descriptions are made from specimens supplied by J. A. Hyslop and taken at Wolfville, Md., May 20, 1913.

The larvae are found in wet mud along the banks of streams or other bodies of water. The species is common in Illinois.

ERIOPTERA Meigen

The larvae of two European species of this genus have been described by Beling. He does not appear to have paid much attention to the structure of the head of any larva that he described, the only characters mentioned being those of general shape, armature, or clothing of the body, the absence or presence of pseudopods, and the shape of the apical segment. The species, judging from his description, differ from those of allied genera in having the thoracic segments distinctly swollen and the body noticeably tapered posteriorly. The apical segment is armed with 5 short processes as in *Gnophomyia* and *Helobia.*

The species described by Hart as *Erioptera* species (*a*) in his paper on the Entomology of the Illinois River, is not an *Erioptera* according to this generalization, but is, I think, much more closely related to *Gnophomyia* than to *Elliptera,* contrary to Mik's opinion*. I figure

*Wiener Ent. Zeit., Vol. 16, 1898, p. 62.

the head of this species and briefly describe it on a subsequent page of this paper under the heading Genus incertus 2.

Subfamily HEXATOMINAE

SUBFAMILY CHARACTERS

Larva (Pl. XXXIV, Fig. 14).—Very slender; aquatic or semi-aquatic. Head flattened, not so heavily chitinized as in other subfamilies (Pl. XXXIV, Fig. 12). Maxillae with a long, slender, pointed process at outer anterior angle, the processes having been erroneously designated as maxillary palpi by some authors. Antennae short and slender. Labial plate not chitinized, indistinguishable. Mandibles long and slender, sickle-shaped, the teeth confined to base or basal half of inner surface. Body without distinct pseudopods, usually covered with silky hairs; apical segment terminating in 4 slender processes which are fringed with long fine hairs (Pl. XXXIV, Fig. 13).

Pupa.—Head produced in the form of 2 wart-like protuberances at bases of antennae, bases of the latter, especially in male, swollen, their apices extending to or beyond apices of wings. Thoracic respiratory organs long and slender, sometimes acute apically; legs extending well beyond apices of wings. Abdomen with a few weak hairs, the segments, except the basal one, usually with a preapical dorsal transverse band of small spinules.

HABITS OF LARVAE

The larvae of this subfamily are aquatic, but usually, as is the case with other aquatic Limnobiidae, they pupate in the mud alongside the stream in which the larvae occurred. The food consists of algae and vegetable debris.

HABITS OF IMAGINES

The imagines of this subfamily which we have observed, are most active in the late afternoon, flying in swarms over streams or along their margins. Usually they are sluggish, and may be swept from rank herbage along stream margins. I do not know their food-habits.

KEYS TO GENERA

LARVAE

1. Lower process on each side of apical abdominal segment with a very long terminal hair in addition to the fringe of short hairs along margin.......................................*Penthoptera.*

— Lower process on each side of apical abdominal segment with only the fringe of short hairs, no long terminal hair being present. . .2

2. Labrum with a leaf-like lobe on each antero-lateral angle which is directed anteriorly and mesad, the pair almost meeting so as to shield the anterior margin of the labrum. . . . .*Hexatoma.*

— Labrum either rounded or but slightly produced at the antero-lateral angles, lobes, if present, not directed mesad, and the apices of the pair widely separated. . . . .*Eriocera.*

PUPAE

1. Apices of fore tarsi ending much proximad of apices of mid and hind pairs. . . . .*Hexatoma.*

— Apices of fore tarsi ending on a transverse line with mid pair, the hind pair sometimes extending distad of the latter. 2

2. Thoracic respiratory organs very noticeably swollen at bases and apices, the constricted central portion with transverse wrinkles. . . . .*Penthoptera.*

— Thoracic respiratory organs of nearly uniform thickness throughout their length, sometimes tapering from near base to apex. . . . .*Eriocera.*

I have before me a number of larvae of this subfamily, but can associate none of them with a described species as neither pupa nor imago are in the collection. Our specimens, with but one exception, were obtained by Dr. S. A. Forbes in rivers in Yellowstone National Park; the single one was taken by Dr. C. C. Adams in Montana. The species in their larval stage appear to be confined to swift-flowing streams. No examples have been obtained in Illinois though much careful work has been done on the Illinois River. It is not improbable that an examination of some of the smaller swift-flowing streams in the more hilly sections of the state will discover the presence of these larvae. They are usually found under stones when in the current, but come ashore to pupate in the sand or mud of the banks.

The species almost invariably have the appearance of Figure 14, Plate XXXIV, when preserved, the integument of the penultimate segment distending remarkably in some specimens. Brauer, in his paper previously referred to, has figured a species with this characteristic distension. The long membranous appendages of the maxillae probably serve the purpose of guiding the food into the mouth, being analogous to the mouth-fans of the family Simuliidae—also found in swift-flowing waters.

Subfamily TRICHOCERINAE

I have before me a single specimen of the larva of a species of *Trichocera*. The pupa is unknown to me.

In many respects the larva resembles that of *Rhyphus*, but the affinities of the imago are clearly with the Limnobiidae, and for this reason I retain it here, though with some hesitation.

Trichocera Meigen

GENERIC CHARACTERS

Larva.—Head different from that of all other Limnobiidae in having a complete capsule, closely resembling in this respect Ptychopteridae and Rhyphidae, the ventral surface especially resembling that of the latter; mandibles stout, with distinct teeth. Body covered with decumbent pile. Prothorax with distinct spiracles. The apical segment is noticeably more slender than the preceding one and armed with 4 finger-like processes surrounding the spiracles.

Pupa.—Head and thorax with hairs much as in Rhyphidae, the cephalic hairs very similar to those of *Limnophila*. The thoracic respiratory organs are horn-like. The abdomen is armed as in *Limnophila* and has incisions similar to those present in that genus.

Imago.—See key to subfamilies.

HABITS OF LARVAE

The larvae are found in decaying vegetation and under leaves.

HABITS OF IMAGINES

The genus *Trichocera* contains the so-called "winter-gnats" of Europe. They fly in mild weather throughout almost the entire winter in Britain, and are frequently seen flying over snow and settling upon it where the sun falls on it.

It is remarkable that this very common genus is unrepresented in the materials in our Illinois collection.

Trichocera sp.?

Larva (Pl. XXXVI, Fig. 1).—Length, 7.5 mm. Pale testaceous, the head with brown marks on each side of central sclerite of dorsum in front of antennae, and along posterior margin.

Antenna small, consisting of a slender apical process situated on

an elevated base; mandibles similar to those of Rhyphidae in that they consist of a stout basal piece and an articulated apical one, the latter with several teeth; labium small, rounded anteriorly, the appendage above it (mentum) similarly shaped, both armed with numerous hairs (Pl. XXXVI, Fig. 10); labrum overhanging oral orifice, the epipharynx armed with numerous strong spinules; maxillae and their palpi similar to those of *Rhyphus punctatus*; eyes pigmented, situated on side of head instead of being on dorsum as in *Rhyphus*. Body with short decumbent pile; segments of thorax bisected, those of abdomen trisected; pseudopods absent; apical segment with 4 finger-like processes, the lower pair longer than the upper and furnished with some delicate hairs at apices.

The specimen described above was taken by A. G. Whitney on St. Paul Island, Bering Sea, March 23, 1913, and formed part of a collection submitted to me for identification by the U. S. Bureau of Biological Survey.

Limnobiid Larvae of Uncertain Generic Location

I have based the synoptic key to the larvae of the subfamilies upon species that I have reliable identifications for, but certain larvae that I have before me are not in agreement with the characters cited, or they so vaguely resemble those that are identified as belonging to the various subfamilies that I have deemed it wisest to describe them independently, in the hope that further light may be shed upon their position in the classification by some student of the group who may succeed in rearing them.

I realize that there are in store for us many surprises in the larval and pupal characters of species that are as yet unknown in these stages, and hope that the present effort to assign characters for the separation of the subfamilies may be improved upon rapidly after it appears in print.

Genus incertus 1

Larva (Pl. XXXV, Fig. 11).—Length, 10 mm. Golden yellow, covered with silky hair which gives the larva a satiny appearance. Tapering on thoracic segments towards head. Head almost completely retractile, ventral aspect as in Figure 16, Plate XXXV; oesophagus conspicuous, its sides with very prominent ridges which meet angularly in center; maxillary palpi 2-jointed, of moderate size; mandibles barely distinguishable in mount (see figure last mentioned); posterior portion of head consisting of 4 rods, the dorsal pair more elongated

than the ventral and thickened apically. Thorax and abdomen densely covered with closely appressed silky pile; dorsum of thoracic and abdominal segments each with a transverse series of short, closely placed, backwardly directed spines at suture, the abdominal segments with 3 additional transverse series which do not traverse the whole dorsum and are usually interrupted in one or two of the series; ventral segments each with 2 transverse series of similar locomotor spines on all but the apical 4, these latter bearing a series at the sutures and a transverse mouth-like incision with slightly protruded membranous integument which is densely clothed with short upright hairs (Pl. XXXV, Fig. 14); hairs in front of the transverse incision on apical segment very long; locomotor spines barely distinguishable except when the larva is alive and in motion; apical segment terminating in 4 rather long stout processes, on the inner under surface of the upper pair of which are the black, round, posterior spiracles, and on the lower pair a long apical hair (Pl. XXXV, Fig. 13).

The larva just described is one that I took from a much-decayed log at White Heath April 30, 1916.

It conforms to the general characteristics of the larvae of this family, but I have no means of determining its specific identity as the only specimen I obtained died before pupation.

The head and thoracic segments were dissected and mounted in Canada balsam; the remainder preserved in alcohol.

The structure of the head points to the likelihood of the species belonging to Eriopterinae.

Genus incertus 2

Larva (Pl. XXXIV, Fig. 8).—Length, 5–7 mm. Yellowish white, with the head and locomotor areas showing blackish.

Head as in Figures 1, and 4, Plate XXXV, the general shape resembling that of *Limnobia*; mandibles stout, with apical and lower marginal teeth; labial plate of the same form as in *Limnobia*. Body slender, the segmentation distinct; locomotor organs consisting of transverse, elevated, slightly leathery areas which are not armed with spinules, their number and arrangement as in Figure 8, Plate XXXIV. Apical segment terminating in 2 long tapering processes which are armed with a number of long hairs, as in Figure 15, Plate XXXIV. Spiracles situated on dorsum at base of terminal processes, their openings not conspicuous nor chitinized.

Described from 4 specimens obtained by Dr. S. A. Forbes from Firehole River below Nez Perce Rock Rapids, Yellowstone National Park, August 16, 1890.

The description of the larva of *Trimicra pilipes* Meigen is not unlike that of the present species, but in the former the locomotor organs consist of paired pseudopods, and it is probably a true pediciine species, whereas the one above described may prove to be an aberrant limnobiine, resembling Pediciinae only in the structure of the apical segment.

Genus incertus 3

This is the larva described and figured by Mr. Hart as *Erioptera* species (*a*). Judging from the characters of the larvae of *Erioptera* summarized on a previous page this species does not belong to that genus. The head is quite different from that of *Helobia,* the dorsum being much more compact, as is shown in Figure 19, Plate XXXIV. I believe that the species really belongs to Eriopterinae, as the superficial characters ally it more closely with that subfamily than with any other. The larva and its apical segment are shown in Figure 8, Plate XXIX, and in Figure 5, Plate XXX, respectively.

For a full description of the species see Mr. Hart's description*. The larva lives among floating weeds in the Illinois River.

Genus incertus 4

Larva.—Length, 15 mm. Slender, the segments distinctly longer than broad, the body of almost uniform thickness.

Head very similar to that of *Helobia*, the median posterior rod even more slender than in that genus; dorsal plate (fronto-clypeus) longer and more slender and pointed than in *Helobia;* maxillary palpi tapering, extending very much beyond the apex of labrum, with distinct constrictions on apical third, giving them the appearance of having 3 joints. Body covered with dense yellow decumbent pile, most conspicuous at posterior margins of thoracic segments because there it is slightly turned upward. Abdomen without distinct locomotor organs; penultimate segment swollen much as in Hexatominae; apical segment with 4 short backwardly directed protuberances, the upper pair distinctly shorter than the lower; anal blood-gills inconspicuous.

The foregoing description was made from a specimen in the Laboratory collection bearing the accession number 26785, the accompanying data being as follows: Blacktail Deer Creek, Yellowstone National Park, August 28, 1890; taken under stones in the water (S. A. Forbes).

---

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 198–199.

This species closely resembles Genus incertus I of this paper in head-structure and appearance, differing however in the absence of pseudopods. It undoubtedly belongs to the Eriopterinae.

PAPERS ON THE BIOLOGY OF NORTH AMERICAN LIMNOBIIDAE*

Cylindrotominae

Alexander, C. P.

'14. Biology of the North American crane flies (Tipulidae, Diptera). II. Pomona Coll. Jour. Ent. and Zool., 6:105. (Contains full bibliography of the immature stages of the group.)

Osten Sacken, C. R.

'69. Monographs of North American Diptera. Part IV, p. 296. (Contains synopses of genera and species of imagines.)

Limnophilinae

Alexander, C. P.

'15. The biology of the North American crane flies (Tipulidae, Diptera). III. The genus *Ula* Haliday. Pomona Coll. Jour. Ent. and Zool., 7:1.

Hexatominae

Alexander, C. P.

'14. The biology of the North American crane flies (Tipulidae, Diptera). I. The genus *Eriocera* Macquart. Pomona Jour. Ent. and Zool., 6:12.

'15. The biology of the North American crane flies. IV. Tribe Hexatomini. Pomona Jour. Ent. and Zool., 7:141.

Family *PTYCHOPTERIDAE*

FAMILY CHARACTERS

Larva.—Head complete; mandibles opposed. Body long and slender, with well-developed pseudopods armed with spines or bristles; many of the hairs on head and body plumose; larva metapneustic, the tracheae extensile, in the form of a long slender membranous tube.

Pupa.—Thoracic respiratory organs very unequal in length, one many times as long as the other; fore tarsi overlying mid pair.

Imago.—Separable from Tipulidae and Limnobiidae by the absence of the seventh longitudinal wing-vein, and the rather poorly defined mesonotal suture.

*See also papers listed in the bibliography of Tipulidae.

HABITS OF LARVAE

The larvae are found in damp situations, frequently in water, and feed upon decaying vegetation and algae.

HABITS OF IMAGINES

The imagines are usually found near streams or other bodies of water. They are frequently taken upon flowers. Several species of *Ptychoptera* are common in Europe, but they are much less so in North America, occurring but rarely in Illinois.

Key to Genera

LARVAE

1. Body with transverse series of wart-like elevations surmounted by hairs; ventral cephalic sclerite conspicuously narrowed posteriorly .... *Bittacomorpha.*

— Body without transverse series of wart-like elevations, but armed with hairs in transverse series; ventral cephalic sclerite slightly narrowed posteriorly .... *Ptychoptera.*

Bittacomorpha Westwood

This genus is represented by many examples of *clavipes,* in all stages, in the collection before me. This material was used by Mr. Hart in drawing up his description of the larval and pupal stages in the paper frequently mentioned herein. The superficial characters of the larva and pupa are well illustrated by Figures 4 and 6, Plate XXX. The following description should be regarded as supplementary to the previously published one.

Bittacomorpha clavipes Fabricius

Tipula clavipes Fabricius, Mantissa Insectorum, Vol. 2, p. 323. (1787)

Larva (Pl. XXX, Fig. 4).—Length, including extended respiratory tube, 50–60 mm. Pale brownish, with the dorsal surface of head marked with dark brown granulose elevations, and the transverse series of warts on body darker than remainder of ground-color (Pl. XXXV, Fig. 5).

Ventral surface of head as in Figure 8, Plate XXXV, the central sclerite very much narrowed posteriorly, the anterior margin concave; maxillary palpi and antennae longer than in *Ptychoptera;* labrum seen from above about half as long as broad; mandibles as in

Figure 15, Plate XXXV, a strong tooth on outer surface much before apex. Three pairs of distinct ventral pseudopods present, one on the posterior margin of each of the basal 3 abdominal segments, each pseudopod armed with a strong curved apical claw that may be retracted at will (Pl. XXX, Fig. 2); two protrusive blood-gills at base of respiratory tube.

Pupa (Pl. XXX, Fig. 6).—Length, inclusive of respiratory organ, 50–60 mm. Color like that of larva.

One thoracic respiratory organ very long, usually longer than body, the other aborted. Palpi very long, curved forward; antennae shorter than in Tipulidae and but little curved; fore tarsi concealing a portion of mid pair; arrangement of parts as in Figure 6, Plate XXXV.

This species is aquatic, living among floating vegetable debris. The imagines have been taken in various parts of the state, but the only Laboratory record for the larvae is Havana, on the Illinois River.

PTYCHOPTERA Meigen

I have found in the collection here a number of larvae of *Ptychoptera* taken more than twenty-five years ago by Dr. S. A. Forbes. As the species was not reared and the pupal stage is not in the collection, I am unable to compare the pupae of the genera or to give a specific identification for the form before me.

PTYCHOPTERA sp.?

Larva (Pl. XXXV, Fig. 12).—Length, 18–20 mm. with anal respiratory tube retracted. Differs noticeably from the larva of *Bittacomorpha* in the structure of the head and body, none of the corresponding parts of the two genera bearing more than a general resemblance to each other. The ventral sclerite of the head is very much broader than in *Bittacomorpha* and does not narrow so decidedly posteriorly; the mandibles differ from those of *B. clavipes* in having a number of stout spines on their outer surface before apex instead of a very strong tooth; the labrum is about 4 times as broad as long; and the surface of the head is smooth and almost unicolorous. A comparison of Figures 7 and 10, Plate XXXV, with those of *Bittacomorpha* (Pl. XXXV, Figs. 5, 8) will illustrate the main distinctions between the genera. The body differs from that of *Bittacomorpha* in lacking the transverse series of wart-like elevations that are so conspicuous in that genus.

The two lots of larvae from which the foregoing description was made, were collected by Dr. Forbes in Yellowstone National Park in 1890, one on August 8, in Yellowstone Lake, and the other on August 13 in Alum Creek, both collections being obtained among weeds.

Family *RHYPHIDAE*

This family is very small, containing only three genera from North America. One of these, *Myctobia,* has been but lately assigned to the family, having previously been regarded as belonging to the Mycetophilidae. According to the differentiating characters previously considered by taxonomists as of family value, *Mycetobia* appears to belong to Mycetophilidae rather than to Rhyphidae; but the larval and pupal characters unmistakably ally it very closely with *Rhyphus.* The early stages of *Olbiogaster* are not known to me. I have before me all stages of *Rhyphus punctatus* Meigen and *Mycetobia divergens* Walker, and describe and figure them herewith.

FAMILY CHARACTERS

Larva.—Very slender, tapering towards extremities. Head complete, subconical; antennae distinct; mandibles opposed; maxillary palpi poorly developed. Thoracic segments simple, longer than broad, and, like those of abdomen, circular in transverse section; prothoracic spiracles distinct. Abdominal segments divided transversely as in Therevidae; pseudopods absent; apical segment tapered; spiracles of moderate size, terminal, surrounded by 5 short processes in *Rhyphus.*

Pupa.—Slender. Head, between antennae, with 2 slight protuberances, each of which is surmounted by a weak hair; antennae curved round in front of and over upper margin of eyes, extending to bases of wings; palpi straight on apical portion and directed laterad. Thoracic respiratory organs but little elevated; fore tarsi overlying mid pair, the latter overlying hind pair, both mid and hind pairs surpassing apices of wings. Abdomen armed with 2 transverse series of thorns on each segment; spiracles small but distinct.

Imago.—The imagines of the three genera are more diverse in structure than are the genera in most families of the Nematocera, and it is possible that some future writer may separate them. A generalization of the generic characters will be found in the synoptic key to the Nematocera on a previous page.

HABITS OF LARVAE

The larvae of *Rhyphus* are found in manure, decaying vegetation, and occasionally in cesspools or bodies of stagnant or impure water; those of *Mycetobia* are found in wounds on trees, feeding upon the exuding sap and its attendant fungus. Rarely both genera are found together.

I have found nematode parasites in the larvae of *Mycetobia* at Urbana, Ill.

HABITS OF IMAGINES

Both *Rhyphus* and *Mycetobia* are found commonly on tree-trunks and on windows in houses. They feed upon nectar and liquid matter.

Keys to Genera

LARVAE

1. All segments conspicuously marked with dark brown; head but little shorter than prothorax; apical segment with 5 short but distinct processes round the spiracular disc.............. *Rhyphus*.
— Only the thoracic segments conspicuously marked, the markings yellowish or very pale brown; head conspicuously shorter than prothorax; apical segment with microscopic processes round the spiracular disc which are invisible except under a very high-power lens.. *Mycetobia*.

PUPAE

1. Spiracular opening of the prothorax rather large, circular, distinctly but not greatly elevated; thorns in transverse series near posterior margin of each abdominal segment rather widely separated .... *Rhyphus*.
— Spiracular opening of moderate size, situated upon a conspicuous tubercle, with a ridge-like elevation extending caudad of it; thorns in transverse series near posterior margin of each abdominal segment close together, generally contiguous............ *Mycetobia*.

IMAGINES

1. Discal cell of wing absent........................... *Mycetobia*.
— Discal cell of wing present.................................. 2
2. All branches of radius ending in margin of wing........ *Rhyphus*.
— Second branch of radius ending in first.............. *Olbiogaster*.

Rhyphus Latreille

I have but one species of this genus represented by all three stages, consequently it is unnecessary to summarize the generic characters.

Only four species are recorded from the United States, two of which, *alternata* Say and *punctatus* Fabricius, occur commonly in Illinois.

Rhyphus punctatus Fabricius

Rhagio punctatus Fabricius, Mantissa Insectorum, Vol. 2, p. 333. (1787)

Larva.—Length, 9–10 mm., diameter, .75 mm. Yellowish white, with the greater portion of each segment marked with fuscous brown, the dark portion containing a number of rounded or elongate pale spots.

Head larger and more tapered anteriorly than in *Mycetobia,* the dorsal aspect as in Figure 4, Plate XXXVI; eye-spots distinct; antennae smaller than in *Mycetobia*; mandibles as in Figure 5, their apices blunt, without well-developed teeth, and obscured apically by long and dense hairs; maxillary palpi small; maxillae hairy; labium as in Figure 12, centrally with a deep incision. Thoracic segments subequal in length; prothoracic spiracles of moderate size, situated on side, about one third from posterior margin of segment. All abdominal segments with a distinct constriction about one fifth from the anterior margin; apical segment with a large smooth plate on ventral surface, the tip of segment with 5 short processes round margin of spiracular disc (Fig. 2).

Pupa.—Length, 6–8 mm. Of the same color as the larva.

Head with the same armature and general structure as *Mycetobia.* Thoracic respiratory organs much less elevated than in that genus, their apices not reaching nearly as far as anterior margin of antennae when seen in profile. Legs and wings as in *Mycetobia,* the principal difference, apart from the thoracic respiratory organs, lying in the armature of the abdominal segments, as indicated in key to genera and in Figures 8 and 9, Plate XXXVI.

I have before me larvae and pupae that I obtained June 24, 1916, from horse-dung at White Heath, Ill., and similar material submitted by J. A. Hyslop, obtained at Hagerstown, Md., from cow-dung.

The species is found in Europe and North America, and is usually very common throughout the warmer portion of the year. The larvae feed in decaying vegetable matter, manure, and occasionally in sewage or foul water. The imagines occur very often upon windows of houses and outbuildings, but are quite frequently found at rest upon tree-trunks. They feed upon exuding sap of trees and upon nectar of flowers.

Mycetobia Meigen

I have before me all stages of the only described North American species of this genus. The early stages have been previously described by Johannsen and myself, and the figures given herewith are merely supplementary to these descriptions, references to which are given in the synonymy of the species.

Mycetobia divergens Walker

Mycetobia divergens Walker, Ins. Saund., Dipt., Pt. 1, p. 418. Imago. (1856)
Mycetophila persicae Riley, Prairie Farmer, June 15, 1867, Vol. 35 (n. s., 5), No. 19, p. 397. Imago.
Mycetobia sordida Packard, Guide to the Study of Insects, p. 388. Imago. (1869)
Mycetobia marginalis Adams, Kans. Univ. Sci. Bull., Vol. 2, No. 2, p. 21. Imago. (1903)
Mycetobia divergens Walker, Johannsen, Bull. 172, Maine Agr. Exper. Station, p. 223. Larva, pupa, and imago. (1910)
Mycetobia divergens Walker, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 321. Larva and pupa. (1915)

Larva (Pl. XXXVI, Fig. 3).—Length, 11–13 mm., diameter, .60 mm. White, semitransparent, thoracic segments marked with yellowish brown.

The principal distinguishing features of this species as compared with *Rhyphus,* apart from the difference in color and shape of the apical segment, mentioned in key, are the more slender build of the body and the dissimilar structure of the head. The greatest difference is apparent in the form of the labial plate and mandibles, as shown in Figure 11, the mandibles in the present species being pointed, and armed on the upper margin with several teeth, while the labium is not centrally incised.

Pupa.—The principal differences between the two genera are emphasized in the key to pupae, and a comparison of Figures 8 and 9, Plate XXXVI, will show the general build of the cephalic, thoracic, and basal abdominal regions, as well as the armature of the latter, in which there are decided differences. The ventral aspect of the head, thorax, and base of abdomen is shown in Figure 6; the dorsal aspect of head and thorax in Figure 7.

The larvae of this species are very commonly met with in wounds on trees from which sap is exuding. They feed upon the sap or the fungus occurring in such situations, and the pupae are found among the loose bark, especially where it is damp. The imagines behave in

much the same manner as do those of Mycetophilidae, hiding away in chinks in the bark of trees, and frequently feigning death when disturbed. They are much more active than *Rhyphus* and generally shun the light, whereas the latter do not appear to do so. The food consists of exuding sap of trees.

Tribe Eucephala

I have retained in this tribe, which is one of those proposed by Brauer, three superfamilies, removing Bibionoidea to Oligoneura. The tribe contains an assemblage of families that show a considerable range of variation in the structure of practically all parts of the body in the larvae, but these all possess a complete head with opposed mandibles and usually a well-developed labium. The antennae are usually well developed, consisting in Chironomidae of four to six joints, but in Mycetophiloidea, exclusive of Bolitophilidae, these organs are rudimentary, being usually very slightly elevated clear spots, contrasting sharply with the dark color of the remainder of the head. Peripneustic forms are present in Bolitophilidae, Mycetophilidae, Sciaridae, and Chironomidae, while some of the other families contain species that have rudimentary abdominal spiracles. I have decided upon the present grouping of the genera after a consideration of the characters of all the stages. This arrangement is quite different from that outlined by de Meijere* in a paper that appeared when my manuscript was almost completed. I am not dogmatic with regard to my arrangement of the families concerned, and it should prove interesting to students to compare the results as presented in the two papers.

As this paper is primarily intended as a handbook for the ready identification of immature forms of Diptera and not as a discussion of affinities, it is deemed inadmissible to bolster the classification suggested by lengthy argumentation. The proving or disproving of the suggested affinities is left to the future, and probably to other students.

In order to locate species of the tribe it is necessary to make use of the keys to the various stages of Nematocera on a previous page.

The structure and habits of the species are dealt with under the family, subfamily, or generic headings.

*Zool. Jahrb., Abt. f. System. Geog. u. Biol., Vol. 40, Pt. 3–4, 1916, p. 307.

Superfamily *Mycetophiloidea*

This superfamily, as at present defined, includes the following families: Bolitophilidae, Mycetophilidae, Sciaridae, Macroceridae, and Platyuridae.

The first three families contain, as I believe, the most primitive larval forms known to me, but the fifth has evolved a form that to my mind shows considerable specialization, while the imagines show less specialization, in so far as the wings are concerned, than do those of Mycetophilidae and Sciaridae. The early stages of Macroceridae are unknown to me.

SUPERFAMILY CHARACTERS

Larva.—Head complete, the sclerites, ventrally, more or less distinctly separated, often connected by narrow chitinized strips; mandibles opposed, toothed; antennae poorly developed except in Bolitophilidae; maxillae differing from those of other Nematocera in having their inner margins serrate; maxillary palpi developed or undeveloped. Larvae peripneustic except in Platyuridae, the latter without distinct lateral abdominal spiracles and with protrusive anal respiratory gills. Abdomen, and sometimes some or all of the thoracic segments, with locomotor spinules, or the entire body without such organs. Abdominal segments in Platyuridae with conspicuous transverse ridges, giving the body an annular appearance.

Pupa.—Head small, sometimes retracted, bringing its anterior margin in line with anterior margin of thorax; antennae elongate, either curved over eyes or projecting in a straight line from upper margin of head to base of wing or slightly beyond that point. Thoracic respiratory organs sessile, very rarely elevated. Wings more or less closely adherent to body; legs long, straight, extending much beyond apices of wings. Abdomen with 6 pairs of spiracles and without distinct armature on dorsum; apical segment sometimes with 4 short spines.

Imago.—The imagines of this superfamily have the radial vein of wings with 2 or 3 branches. The species which have 2 branches only, lack the medio-cubital cross-vein. One of the subfamilies which I have placed in Mycetophilidae has the radius with 3 branches, but the second joins the first and forms a more or less elongated closed cell, and the medio-cubital cross-vein is absent. The antennae are filiform, very rarely thickened, and occasionally remarkably elongated and slender; the proboscis is usually short and fleshy, rarely elongate (*Asindulum* and *Eugnoriste*). For synoptic characters see key to imagines of Nematocera.

Family *BOLITOPHILIDAE*

FAMILY CHARACTERS

Larva.—*Bolitophila* larvae differ from the larvae of Mycetophilidae in having 2-jointed, well-developed antennae, the head subquadrate, and the median dorsal sclerite truncated apically, its sides on posterior half being little or not at all convergent posteriorly. From the larvae of Platyuridae it differs in having well-developed abdominal spiracles and the abdomen without conspicuous transverse elevated ridges.

The pupa is unknown to me.

Imago.—Differs from Mycetophilidae in having the radius with 3 branches and in the presence of the medio-cubital cross-vein, from Platyuridae in its distinct medio-cubital vein, and from other families as indicated under the heading "Notes on Family". The species are generally more fragile than Platyuridae and allied families.

HABITS OF LARVAE

The larvae are mycetophagous, feeding upon fungi growing upon trees, under logs, or in dense woods or in fields.

HABITS OF IMAGINES

The imagines are very rare in North America. They are usually found in woods, and particularly along the sides of ditches or streams in wooded localities, from the grass-grown overhanging banks of which they may often be beaten in spring and fall. They hibernate in these situations in Europe, and very probably in this country also.

NOTES ON FAMILY

There are but two genera in North America that belong to this family, *Bolitophila* and *Palaeoplatyura*. *Hesperinus*, which has been placed here, possesses only 12 antennal joints and belongs to the Bibionidae. Johannsen expressed an opinion to this effect in his paper on the Mycetophilidae*. The subfamily Mycetobiinae of Johannsen's paper is also, I am certain, composed of genera that are not closely allied. *Palaeoplatyura* very probably belongs to Bolitophilidae, where I have placed it, while *Ditomyia* and *Symmerus* should form a family by themselves. *Palaeoplatyura* is more closely related to *Bolitoph-*

*The Fungus-gnats of North America, Pt. I, p. 222. (1910)

ila than to *Mycetobia*, as is evidenced by the complete media, and by the presence of the subcostal cross-vein in *P. johnsoni*. *Ditomyia* and *Symmerus* both lack the basal part of media and the subcostal cross-vein, while, in addition, the subcostal vein is incomplete. *Mycetobia* belongs to Rhyphidae.

There are two North American species of *Palacoplatyura*, and four of *Bolitophila*,—two of which, *cinerea* and *hybrida*, occur also in Europe.

Key to Genera

1. Medio-cubital cross-vein proximad of radio-medial, so that the 2 cells separated by basal portion of media are very unequal in length.......................................*Bolitophila*.
— Medio-cubital cross-vein almost in vertical line with radio-medial, so that the 2 cells separated by basal portion of media are almost equal in length...........................*Palaeoplatyura*.

Key to Imagines of Bolitophila Meigen

1. Fork of third vein ends in first branch of radius (Europe; N. Y.) ....*cinerea* Meigen*.
— Fork of third vein ends in costa...............................2
2. Anterior branch of cubitus discontinued some distance from base (Idaho; N. H.)..............................*disjuncta* Loew.
— Anterior branch of cubitus complete..........................3
3. Subcostal vein ends in costa at a point above or beyond the base of radial sector—third vein (N. H.; Ind.; B. C.)..*hybrida* Meigen.
— Subcostal vein ends in costa at a point much proximad of base of radial sector (N. H.; N. Y.)...............*montana* Coquillett.

Key to Imagines of Palaeoplatyura Meunier

1. Wings unmarked; subcostal cross-vein absent (Wash.)........... ....*aldrichi* Johannsen.
— Wings with grayish or fuscous markings; subcostal cross-vein present (Vt.)..............................*johnsoni* Johannsen.

*The larva of *Bolitophila cinerea* has been figured and briefly described by Dr. Felt in the Twenty-ninth Report of the New York State Entomologist, p. 67. (1915)

Family *MYCETOPHILIDAE*

The limits of this family are somewhat doubtful, and the most recent papers on it seem to me to include a rather heterogeneous assemblage of genera that require considerable family subdivision. The

importance of certain structural details of the imagines is not sufficiently realized as yet, and as we gradually accumulate data upon the larval and pupal stages I am confident that certain groups at present considered as genera in the family will be elevated to subfamily, and some even to family, rank. I have taken upon myself the responsibility of separating some of the so-called subfamilies from Mycetophilidae—a step which I consider justified because of distinctions which are evident in the adult insects, and also in the known larvae and pupae.

FAMILY CHARACTERS

Larva.—Head complete, not very heavily chitinized, usually conspicuously different from the remainder of body in color; antennae usually short, appearing in many genera as pale rounded areas on each side of head near anterior margin; mandibles toothed; maxillae well developed, their inner surfaces usually conspicuously dentate; maxillary palpi developed or very slightly so; labium not in the form of a flat plate; median dorsal sclerite of head tapering to a point posteriorly. Ventral surface of thoracic and abdominal segments sometimes with a transverse band of black locomotor spinules, which are occasionally very conspicuous; prothoracic and first 7 abdominal segments each with lateral spiracles; apex of abdomen simple; anal spiracles terminal.

Pupa.—Head unarmed; antennae curving well over upper margins of eyes, forming a semicircle and ending about middle of wings along their costal margins. Thorax conspicuously elevated, the anterior margin almost vertical, the dorsum appearing in lateral view almost globose; spiracles not elevated; legs elongated; entire fore legs visible; mid coxae visible only in part; apices of all legs extending beyond apices of wings, those of the hind pair sometimes reaching apex of abdomen. Abdomen unarmed; 7 pairs of spiracles present, the basal pair usually hidden by wings.

Imago.—As limited in this paper this family contains only those genera that belong to the following subfamilies of Johannsen's paper on Mycetophilidae: Diadocidiinae, Sciophilinae, and Mycetophilinae. I consider that these three groups really constitute separate families, but in the absence of larval and pupal material as criteria I prefer to leave matters at present as they are, hoping at some future time to elucidate further their relation, or that some other student of the order may find time to do so.

HABITS OF LARVAE

As the popular name, fungus-gnat, indicates, the larvae feed upon fungi in the great majority of cases. The species of fungi they attack and the situation in which the larvae are found differ very considerably. Many species feed upon *Agaricus* and allied genera in open situations; some feed upon *Polyporus* and other fungi growing upon living or dead trees; while others feed upon minute fungoid growths upon the under surfaces of fallen trees, rails, or boards upon the ground, and a few appear to live entirely upon vegetable matter in an advanced stage of decay. Nearly all the larvae spin webs in the galleries they make in their food; in the case of species that live externally upon fungi the web is slimy, rather loose, and irregular. I have paid particular attention to some species I have reared, and find that the larvae of this last group do not pass over the threads but through them, as in a tube, the body being enclosed except anteriorly. The threads are slimy in nature, and the presence of the larvae may be detected by the glistening surface of the fungus, which appears as if a slug had crawled over it. The larvae, as far as I have observed, spin a cocoon of a more or less compact nature to pupate in. In the case of *Leia* the pupa is simply suspended by means of a number of loose threads which keep it from the surface of the fungus or other matter in which it is found, and very probably safeguard it to some extent, as mites seem unable to cross the threads.

HABITS OF IMAGINES

The imagines are found in a variety of situations, but most commonly in damp and rather dark places, especially where there is fungoid growth. Damp basements, old outhouses, and hotbeds, usually yield many species. In woods the greatest number may be obtained by sweeping amongst undergrowth in the most shady spots, though a number of species may be found on tree-trunks, where they run with surprising speed. Several species occur upon flowers, but the majority of them only in the late afternoon. Many species will on occasion feign death, but spring to life suddenly when touched. I have found specimens still enclosed within their loose silken cocoon when collecting under bark in spring. When touched the insects make a hurried exit only to feign death after progressing a few inches, and by means of alternate rushes and pauses they soon succeed in burying themselves under any loose detritus that is convenient.

Keys to Subfamilies

LARVAE

1. Head usually deep black, only the antennal sockets and some small round spots pale; maxillary palpi not protruded ....MYCETOPHILINAE.
— Head pale, antennal sockets surrounded by a black band; maxillary palpi sometimes protruded (*Sciophila*)...........SCIOPHILINAE.

PUPAE

1. Thoracic and abdominal respiratory organs sessile; slender species; legs and wings not closely fused together and to thorax...MYCETOPHILINAE.
— Thoracic and abdominal respiratory organs elevated; robust species; legs and wings closely fused to each other and to thorax...SCIOPHILINAE.

IMAGINES

1. Medio-cubital cross-vein present; radius with 2 branches...DIADOCIDIINAE.
— Medio-cubital cross-vein absent..............................2
2. Radius with 3 branches, the intermediate one connecting first and third usually near base of latter and forming a subquadrate or oblong cell....................................SCIOPHILINAE.
— Radius with 2 branches........................MYCETOPHILINAE.

Subfamily MYCETOPHILINAE

I have obtained the larvae and pupae of representatives of two genera of this subfamily. The larvae of these genera differ very markedly from each other though the pupae are very similar.

SUBFAMILY CHARACTERS

Larva.—Head glossy black; antennae sessile; a conspicuous pellucid spot on each side of head below antennae; dorsal sclerite of head gradually tapered from before middle to posterior margin; maxillary palpi sessile, in the form of a rounded pellucid spot; entire inner margin of maxillae serrated; mandibles with 3 or more strong apical teeth, or with a continuous series of short teeth along one margin. Prothoracic and abdominal spiracles present. Locomotor organs indistinguishable or well developed, consisting, when present, of 2 transverse series of spinules on ventral segments.

Pupa.—More slender than pupa of Sciophilinae, and with legs and wings less closely adherent to each other and to thorax. The thoracic respiratory organs and the lateral abdominal spiracles are sessile; in *Leia* the basal abdominal segment has the spiracles rudimentary. The legs of the two genera are of different lengths.

HABITS OF LARVAE

The larvae of most genera of the subfamily are fungivorous, some feeding internally and some externally. Those that feed in the stems or other parts of fungi line their burrows with a slimy substance, while those that feed externally move inside of tube-like slimy threads.

HABITS OF IMAGINES

The imagines feed upon nectar and exuding sap of trees. They very frequently feign death when disturbed, and at other times squeeze themselves into very small cracks or openings in an effort to escape capture or injury.

Keys to Genera

1. Locomotor spinules indistinguishable or very weak........... *Leia*.
— Locomotor spinules strong, black, forming a conspicuous transverse band on each ventral abdominal segment............. *Exechia**.

PUPAE

1. Legs quite dissimilar in length, apices of fore tarsi extending to base of fifth segment of abdomen, those of mid pair to apex of sixth, and those of hind pair to base of eighth............ *Leia*.
— Legs of nearly uniform length, terminating at apex of abdomen in a slightly concave transverse line...................... *Exechia*.

Leia Meigen

This genus contains a number of common and widely distributed species, which are usually conspicuously marked with black on a reddish yellow ground-color, and often have distinctly marked wings.

GENERIC CHARACTERS

Larva.—Head glossy black, much longer than broad, the posterior margin not excised; antennae very short and fleshy; pellucid spot be-

*Some species of *Mycetophila* have locomotor abdominal spinules similar to those of *Exechia*, as described above. Osten Sacken figures the lateral cephalic sclerites of *Mycetophila signata* with rounded productions of their inner posterior extremities.

low antennae distinct; median dorsal sclerite pointed posteriorly. Thorax and abdomen without locomotor spinules; thoracic and abdominal spiracles distinct, the openings blackened.

Pupa.—Anterior margin of thorax declivitous; thoracic spiracles not elevated; antennae elongate, curved well over eye and ending about middle of wing; fore, mid, and hind legs ending at different distances from apices of wings; abdomen without noticeable armature.

HABITS OF LARVAE

The larva lives in a loose slimy web on damp rotten wood or on fungus, and the pupa is found suspended in the threads. The larvae are very active, moving within the slimy tubular thread, either forward or backward, with great facility, and in their behavior resembling some tortricid larvae of the Lepidoptera.

HABITS OF IMAGINES

The imagines closely resemble those of *Mycetophila* and are found in the same situations—sometimes on flowers, on windows, or under logs, and not uncommonly at lights. I have found *L. oblectabilis* in hundreds on the walls and windows of the Natural History Building here in July and August.

LEIA OBLECTABILIS Loew

Glaphyroptera oblectabilis Loew, Berl. Ent. Zeitschr., 1869, p. 146.

Larva.—Length, 11–13 mm. White, semitransparent; head glossy black.

Median dorsal sclerite of head tapering gradually from before middle, ending in an acute point at posterior margin (Pl. XXXVII, Fig. 1); antennae not elevated, represented by rounded, pale, membranous areas; pellucid spot below antennae large and rounded; mandibles with 3 large teeth and 2 small ones on outer margin, and 3 or 4 on inner surface (Pl. XXXVII, Fig. 10); maxillae serrate on inner margin, the palpi not well-developed (Fig. 13); ventral surface of head as in Figure 14 of plate mentioned, the posterior excision cordiform; hypopharynx as in Figure 8. Prothoracic and abdominal spiracles small, the latter especially so. Abdomen glabrous, no locomotor organs distinguishable.

Pupa (Pl. XXXVII, Fig. 5).—Length, 5–6.5 mm. White, becoming darker and showing the markings of the imago as the latter nears emergence.

Head without protuberances; antennae extending beyond base of wing; palpi straight, directed laterad; wings extending slightly beyond base of fourth abdominal segment; fore tarsi extending to base of fifth, mid pair to base of seventh, hind pair to base of eighth. Abdomen glabrous; 6 pairs of well-developed lateral spiracles present, basal pair rudimentary.

Described from a number of specimens obtained by myself at White Heath, Savoy, and Urbana, Ill., in June, July, and September, 1915–16.

Exechia Winnertz

As I have but one species of this genus represented by other than the imaginal stage, the generalization for the larval and pupal stages may not apply to all species of the genus.

GENERIC CHARACTERS

Larva.—Head not much longer than broad, posterior margin with a central and medio-lateral excision on dorsum; central plate tapered gradually from before middle, ending in a rounded point at posterior margin; antennae sessile; pellucid spot below antennae distinct; mandibles rounded, with numerous short teeth; maxillae normal, their palpi larger than those of *Leia*; ventral excision as in that genus. Body with locomotor organs on venter, each consisting of 2 transverse series of black spines; spiracles conspicuous, the prothoracic pair slightly elevated and with 4 openings.

Pupa.—Similar to the pupa of *Leia*, but differing in the length of the legs.

HABITS OF LARVAE

The larvae are fungivorous, feeding usually in the stems of mushrooms. They commonly line their burrows in the stems with a slimy fluid similar to that excreted by *Leia*. Pupation takes place in the burrows.

The species which I have reared, or attempted to rear, are often killed by a hymenopterous parasite when on the point of pupation.

HABITS OF IMAGINES

The species frequent woods, especially the denser parts, and may often be taken in great numbers about fungi. They very often occur

on the windows of houses, particularly in the evening, and they are readily attracted to lights.

In Britain many species of this and allied genera occur during winter in clumps of grasses and ferns overhanging streams and ditches, and this fact seems to indicate that they hibernate as adults.

ExecHIA NATIVA Johannsen

Exechia nativa Johannsen, Bull. 200 Maine Agr. Exper. Station, p. 70. (1912)

Larva (Pl. XXXVII, Fig. 3).—Length, 8–9 mm. White, head and locomotor spinules black.

Head as in Figure 7, Plate XXXVII; mandibles different from those of *Leia* in having 9 sharp teeth distributed along their entire outer margin (Fig. 6); maxillary palpi much longer than in *Leia* (Fig. 9); hypopharynx as in Figure 11. Thoracic spiracles each with 4 slit-like openings (Fig. 4); abdominal pairs smaller than the thoracic. Locomotor spinules arranged as in Figure 2, Plate XXXVII, the apices of the spinules in the anterior and posterior series directed respectively cephalad and caudad.

Pupa (Pl. XXXVII, Fig. 12).—Length, 4–6 mm. Color at first like that of larva, but later becoming darker, and just before the emergence of the adult the color of the latter is clearly discernible through the pupal skin.

Head unarmed, slightly more retracted than in *Leia*; antennae extending beyond middle of wings; palpi directed straight laterad. Thoracic respiratory organs sessile; wings extending to middle of fourth abdominal segment; legs extending to apex of abdomen, ending in an almost straight transverse line. Abdomen without armature; spiracles slightly elevated.

Described from specimens I collected from the stems of a species of *Agaricus* in the forestry of the University of Illinois, at Urbana, in September, 1915.

The effect of parasitism upon the pupa is shown in Figure 15, Plate XXXVII, the larval skin having been shed but the formation of the pupa prevented.

Subfamily SCIOPHILINAE

This subfamily is unknown to me in the immature stages except by the larval exuvium and the pupae of one species and from published descriptions of the larvae of others. The tracheal system of

Sciophila, as described by several writers, corresponds with that of *Leia* and *Exechia,* as well as with other described genera of Mycetophilinae, in having lateral openings on abdominal segments 1–7. There is however an illustrated published description by Schmitz of the larva of a European species of *Polylepta* that shows no abdominal spiracles. I have not the larva of *Polylepta,* which appears to form a connecting link between this subfamily and Platyuridae. Osten Sacken states that the abdominal spiracles in the species of *Sciophila* known to him were very small, which would seem to indicate a step towards their ultimate elimination as functional organs. Dufour's description and figures of a species of the same genus represent the spiracles as large, the thoracic pair bifid. I have only an exuvium, and give no data on this point.

CHARACTERS OF SUBFAMILY

Larva.—Head elongate; maxillary palpi well developed in *Sciophila* only; cephalic sclerites contiguous medianly on anterior half of their ventral surface, but widely separated on the posterior half. Body very slender; spiracles present on abdominal segments in *Sciophila,* absent in *Polylepta.*

Pupa.—Stout. Head without protuberances; palpi curved forward on their apical halves; antennae curved over upper margin of eyes, extending to middle of wing. Thorax declivitous anteriorly; respiratory organs slightly elevated; wings extending to apex of third abdominal segment; legs parallel, the tips of tarsi reaching to apex of seventh abdominal segment. Abdominal spiracles slightly elevated, absent on first segment in species before me.

Imago.—Distinguished from Mycetophilinae by the furcate third vein, the anterior branch leaving the posterior at right angles and joining the second vein in similar manner, thus forming a subquadrate or elongate closed cell.

Polylepta Winnertz

The larva of one species of this genus, which occurs in caves in Europe, has been described by Schmitz*. This species, *P. leptogaster,* has been recorded from North America, and a summary of the description is given herewith as the original publication is not generally available in this country.

As indicated previously, the larva has no lateral abdominal spiracles, which is at variance with the rule in Mycetophilidae.

*Naturhist. Genootschap in Limburg, Jaarboek, 1912, 4th Note.

Polylepta leptogaster Winnertz

Polylepta leptogaster Winnertz, Verh. zool.-bot. Ges., Vol. 13, p. 746. Imago. (1863)

Larva.—Length, 10 mm. Body worm-like, long and slender, in the middle cylindrical, tapering towards extremities. Functional spiracles present on prothorax only, the tracheal trunks confined to the first 2 thoracic segments, terminating on each side at posterior margin in 2 closed functionless spiracles. Head elongate (Pl. XXXVIII, Fig. 3); antennal sockets surrounded by a chitinized dark band, the antennae rudimentary; maxillary palpi not protruded as figured by Osten Sacken for *Sciophila*, their apices extending very slightly beyond apices of the serrated maxillae; mandible with 5 teeth, the upper one strong, the others becoming progressively weaker to lower one (Pl. XXXVII, Fig. 16); median opening in posterior half of ventral surface of head cordiform. Abdominal locomotor organs very weak.

Pupa.—Undescribed.

This species has been recorded from New Hampshire and Indiana. Schmitz's specimens were obtained in a cave in Europe.

Johannsen records 4 species of the genus from North America.

Mycoma brevivittata Coquillett

Sciophila brevivittata Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 67.

Mycoma brevivittata (Coquillett) Johannsen, Bull. 180, Maine Agr. Exper. Station, p. 176. (1910)

Larva (exuvium).—Head as in Figures 1 and 4, Plate XXXVIII; maxillary palpi short, not surpassing the apices of maxillae; antennae not protruded, the antennal socket surrounded by a black band; mandibles with a double series of teeth, which are very unequal in size (Pl. XXXVII, Fig. 17); median dorsal sclerite of head tapering to a point posteriorly. Tracheal trunks large; prothoracic spiracles distinct; no other spiracles discernible in specimen, but they are rarely visible in exuvia though they may be present in the larva; locomotor spinules not distinguishable.

Pupa (Pl. XXXVII, Fig. 18).—Length, 4–5 mm. Brown, slightly shining; enclosed in a silken web.

Stout; anterior margin of thorax vertical, head not extending to anterior margin of thorax; antennae curved over upper margin of eyes and extending to middle of wing, their bases rounded in profile; palpi not extending to upper eye-margin. Thoracic respiratory organs elevated; surface of thorax with short sparse setulae; wings, antennae,

and legs closely fused to thorax; wings extending to apex of third segment or slightly beyond it; legs extending to apex of seventh segment, their apices forming a slightly concave transverse line. Abdomen with numerous microscopic dorsal setulae; spiracles of first segment obsolete, those on segments 2–7 elevated; metanotum centrally concave anteriorly, so that its length at center is about half that of first abdominal segment, while laterally it is as long as the latter; second segment longer than any of the others; seventh about half as long as sixth; eighth and ninth segments combined equal in length to sixth.

The foregoing descriptions were made from a larval exuvium and pupae, the species being obtained by me in the Augerville woods near Urbana, Ill., June 23, 1916. The larvae were feeding on a fungus growing upon the under side of a log lying upon the ground.

The principal differences between this species and *Polylepta leptogaster,* exclusive of any that may exist in the respiratory system, lie in the structure of the mandibles and of the maxillae, and in the absence of locomotor spinules. Schmitz figures the cephalic dorsum as entire in *Polylepta,* which may be an error.

Family *SCIARIDAE*

The members of this family have until recently been classed as a subfamily of Mycetophilidae, but in this paper and in some papers by other authors they are accorded family rank. There is a striking uniformity of structure in the imagines of *Sciara*—the genus that contains by far the largest number of the included species—and in the larvae known to me there is also a striking similarity in appearance and structure. I have reared but few species, and my generalizations are based upon these.

FAMILY CHARACTERS

Larva.—Head like that of Mycetophilinae, differing principally in having 2 narrow bands of chitin connecting the lateral sclerites on their ventral surface (Pl. XXXVIII, Fig. 2), in having the median dorsal sclerite distinctly and often rather abruptly constricted at or slightly beyond middle (Pl. XXXVIII, Figs. 6, 9), and in the absence of the clear spot below antennae. The mandibles are almost quadrate in outline, have 3 large apical teeth, and usually 2 or 3 smaller ones at inner angle of apex (Pl. XXXVIII, Fig. 14). The general shape of the head in species known to me is subquadrate (Pl.

XXXVIII, Fig. 6). In other respects the larvae closely resemble those of *Leia*, the locomotor organs when present being inconspicuous and the abdominal spiracles black and easily distinguished.

Pupa (Pl. XXXVIII, Figs. 5, 7).—General appearance similar to that of pupae of Mycetophilinae, but differing noticeably in having the thorax much less swollen and not declivitous anteriorly, the antennae much longer, frequently extending to apices of wings, and the fore, mid, and hind legs of conspicuously different lengths, and noticeably shorter than in Mycetophilidae. The abdomen is sometimes furnished with short setulose hairs and has 6 pairs of exposed spiracles as have *Leia* and allied genera, the basal (seventh) pair very small and discoverable only by careful examination and partial dissection of base of abdomen. The legs in many species are very much shorter than in *Sciara prolifica*, which is the species figured, the hind pair sometimes reaching only to apex of fourth segment. The abdomen also lacks the short setulae that are present in *prolifica*.

HABITS OF LARVAE

The larvae are essentially scavengers, feeding upon decaying vegetable matter, and manure, but some species do considerable damage to cultivated mushrooms, and under natural conditions feed on fungi. Occasionally in early spring some species appear in immense numbers in plant-propagating houses, having been introduced in leaf-mold in very late fall or in winter while in the egg or larval stage.

Some species, usually when full-grown, have a peculiar habit of leaving the place where they have fed and traveling on the surface of the ground in a rope-like aggregation, which may attain a diameter varying from an inch to three inches and a length of eighteen inches to five feet and contain several thousand larvae. Some European authors give the size of these ropes as three to four inches wide and twelve to fourteen feet long. This habit has long been known in Europe, and has given the larva the names "rope-worm", "snake-worm", and "army-worm". A few records of this habit in America have appeared, the last I know of being in my paper in the preceding volume of this bulletin.*

This office has on file records of these larvae feeding upon dead white-grubs that were killed by fungi or bacteria.

Some species form a slight shiny tunnel-way in which they live, but it is difficult to detect it in most cases.

*Vol. 11, Art. IV, p. 320. (1915)

HABITS OF IMAGINES

The imagines have much the same habits as Mycetophilidae, but I have rarely seen them feign death as do the imagines of *Cordyla* and *Mycetophila*. *Eugnoriste*, which has a very long proboscis, is commonly found on flowers of *Erigeron* and similar plants. Most species of *Sciara* are common on plants and assumably feed on nectar.

Family *MACROCERIDAE*

I have not found the early stages of any species of this family, and consequently can not include it in my keys to the larvae and pupae.

The species are generally rare in North America, but in Europe several occur rather commonly, especially under overhanging banks of streams in or near woods. In early spring they may be beaten from such banks, where grass or ferns overhang their edges, and from the fact that I have taken some species very late in the fall and again early in the spring I assume that they hibernate in the adult stage.

There is but one genus in the family, twelve species of which are listed by Johannsen. Three species are known to occur in Illinois.

Family *PLATYURIDAE*

FAMILY CHARACTERS

Larva.—Head subquadrate, the labrum slightly protruded; antennae very short; mandibles serrate; maxillary palpi sessile; maxillae serrate; median dorsal sclerite of head not tapering to a point posteriorly. Thorax and abdomen without distinguishable spiracles, the latter with a pair of protrusive blood-gills on apical segment; all segments with a number of flat transverse ridges separated by rather deep and very narrow depressions; entire body slightly flattened and with a narrow lateral extension each side which is crossed by ridges as is the dorsum.

Pupa.—Head more protruded than in Mycetophilidae; antennae broad, projecting upward and backward in a straight line, ending near base of wing. Abdominal spiracles elevated; legs long, the apices of hind pair extending to apex of abdomen.

HABITS OF LARVAE

The larvae live in slimy webs on fungi, usually on the under surface of such as grow upon fallen or decaying timber. They move

freely, usually within the tube-like threads, and frequently turn completely around in these, moving along with a gliding effect. They do not move very rapidly when taken from the webs, and are very fragile. Before pupation they spin an elongate cocoon, which is rounded at each end and consists of rather coarse outer threads and a complete inner gelatinous envelope. To the surface of this inner covering, threads leading from the body are attached, these serving as a means of suspension for the pupa. How the larval skin can possibly be shed without detaching these threads I can not explain, but it is done. The cocoon is itself suspended in a mass of rather loose threads and forms a very pretty object when bedecked with tiny drops of moisture, as it usually is in the damp situations where the species occur.

All the examples that I removed from the cocoons died in the pupal stage—whether because of handling or from other causes I do not know.

HABITS OF IMAGINES

The imagines of this family are taken more frequently upon flowers than are those of Mycetophilidae, and they are not uncommon in shady places in woods and amongst long grass on railroad embankments, especially where old railroad ties are lying.

Ceroplatus Bosc

I have obtained the larvae of two species which I believe belong to this genus and also the pupa of one, but unfortunately failed to rear the species to maturity. The characters possessed by the larvae are summarized herewith. The larva and pupa of a European species (*sesioides* Wahlberg) are phosphorescent.

GENERIC CHARACTERS

Larva.—Semitransparent, white, variously marked with purple. Head as in Figures 10, 11, and 15, Plate XXXVIII; mandibles and maxillae as in Figures 12 and 8. Body slightly flattened dorso-ventrally, the lateral margins slightly produced, somewhat bead-like. Thoracic markings consisting of an irregular longitudinal stripe along sides mesad of the lateral production, and usually a less clearly defined narrow posterior band along the hind margin of each segment. Abdominal segments with a dark band on each of the elevated transverse ridges on each segment, the dark color ceasing

a short distance from the lateral production. In one species the bands are almost uniform in color, but in the other there is a darker spot on each extremity of the posterior band, and there are 5 slight but appreciable interruptions in the dark stripes, giving the dorsum the appearance of having 6 dark longitudinal stripes. The species which has the uniform transverse dorsal abdominal stripes has 5 transverse dark stripes on the ventral surface of each segment, the penultimate one of each series very narrow; the other species has 4 such transverse stripes, and in addition a distinct median longitudinal stripe. The apical segment in both species is as in Figure 13; the lateral pointed blood-gills are retractile.

Pupa (Pl. XXXVIII, Fig. 16).—Entire body without armature, the skin very thin.

Antennae much flattened, their anterior margin produced beyond the anterior margin of thorax. Thoracic respiratory organs sessile; scutellum protuberant; anterior margin of thorax sloping; wings extending to apex of third segment of abdomen; fore tarsi extending to apex of seventh segment, mid pair to apex of abdomen, hind pair reaching slightly beyond apex. Abdomen unarmed; seven pairs of spiracles present.

The foregoing descriptions are based upon examples obtained by the writer at White Heath, Ill., June 24 and 25, 1916. I did not observe indications of phosphorescence in the larval and pupal stages, but made no effort to determine whether it existed, owing to my failure to note the European record until too late to verify it.

Principal Papers on North American Mycetophiloidea

Johannsen, O. A.

'09–'12. The fungus gnats of North America. Parts 1–4. Bull. Maine Agr. Exper. Station, Nos. 172, 180, 196, 200. (Includes all families in my superfamily Mycetophiloidea under Mycetophilidae.)

Osten Sacken, C. R.

'62. Characters of the larvae of Mycetophilidae. Proc. Ent. Soc. Phila., 1: 151–172. (Includes all the families of my Mycetophiloidea, and gives references to previous literature on life histories of the species.

Schmitz, H.

'12. Biologisch-anatomische Untersuchungen an einer höhlenbewohnenden Mycetophilidenlarve, *Polylepta leptogaster* Winn. Natuurhist. Genootschap in Limburg Jaarboek, 1912, 4th Note. (This species occurs in the United States.)

Superfamily *Culicoidea*

This superfamily includes the following families according to the present arrangement: Psychodidae, Blepharoceridae, Culicidae, and Dixidae. The last family has been considered by some writers as a subfamily of Culicidae. There are, however, very marked differences between the corresponding stages of Culicidae and Dixidae which I believe warrant their recognition as distinct families.

SUPERFAMILY CHARACTERS

Larva.—All the larvae of the group make primary or exclusive use of the anal spiracular appendages for respiration, Culicidae making exclusive use of them except in a very few cases. The larvae of this family are distinguished from those of any allied family by the fusion and very noticeable expansion of the thoracic segments. Many larvae of the subfamily Corethrinae (Culicidae) are remarkably specialized in having air-sacs in the thorax and near apex of abdomen, which show as blackish spots, and are without the elongate anal respiratory tubes of the normal forms of the Culicinae. These larvae are sometimes found at great depth in lakes, under anaerobic conditions. The larvae of Blepharoceridae have the thoracic and first and second abdominal segments fused and the head poorly differentiated. The lateral abdominal spiracles in this family are not functional. Some Psychodidae have larvae that superficially resemble those of Blepharoceridae in general form, even having median ventral sucker-like discs on abdomen as that family has; but the thoracic segments are not so closely fused, the head is well differentiated, and the apical segment has a more or less elongated respiratory tube instead of its being rounded. The larvae of Dixidae in general appearance resemble those of Chironomidae, but they differ from the latter in having pseudopod-like protuberances on dorsum of basal two abdominal segments, and the head differs greatly from that of Chironomidae. These characters, in my opinion, taken in conjunction with those of the wing of the adult, associate this family more closely with the Culicidae than with the Chironomidae.

Pupa.—The thoracic respiratory organs are elongated in all families of Culicoidea. The pupae of Culicidae and Dixidae have the legs recurved against the ventral surface of the base of the abdomen so that they scarcely protrude beyond the apices of the wings. The legs in Psychodidae and Blepharoceridae are straight, but do not extend beyond apices of wings, or, at most, but slightly beyond. For other

differentiating characters see key to pupae of Nematocera and descriptions of families.

Imago.—Mouth parts sometimes fitted for piercing, rarely aborted; palpi sometimes remarkably long; antennae from 9- to 15-jointed, often with long plumes or with whorls of hairs; ocelli absent or present. Thorax without complete, well-defined suture. Wings without discal cell; surface often haired or scaled; costa, in all except Blepharoceridae, encircling wing, in the latter the field of wing has numerous longitudinal and transverse creases which give it the appearance of having a secondary venation. Legs very slender except in Psychodidae; in the latter and in most Culicidae, with conspicuous hairs or scales.

Family *PSYCHODIDAE*

FAMILY CHARACTERS

Larva.—Head complete; antennae protuberant; mandibles opposed, toothed, sometimes with long, fringed outer processes; labium usually serrate on anterior margin. Prothorax with distinct spiracles, sometimes protuberant; thoracic and first abdominal segments with a slight central transverse constriction, giving them a biannulate appearance, remaining abdominal segments, except the apical one, triannulate; some of the abdominal segments usually with a chitinized dorsal plate upon each of the annuli; in some cases all the segments of thorax and abdomen have such plates, some of those on thorax being interrupted longitudinally in center to facilitate the rupturing of the skin for the exclusion of the pupa; apical abdominal segment usually more or less elongated, particularly in the species without or with very few dorsal plates, in the form of a tapering tube, chitinized, the pair of tracheal spiracles opening close together at its apex, generally with 4 protuberances which are fringed with soft hairs; surface of body with moderately long bristly hairs, variously arranged in the different species.

Pupa.—Prothoracic spiracles elevated, stalk-like; head parts, legs, and wings distinct, closely adherent to body; fore tarsi overlying mid pair, the latter overlying hind pair; apices of hind legs not projecting beyond apices of wings. Dorsal appearance of body in *Maurina* oval in outline, without a distinct break at base of abdomen; the dorsoventral elevation very slight, so that the pupa appears somewhat in the form of an oval scale (onisciform) without projecting spines or bristles on dorsum. In *Pericoma* and *Psychoda* the pupa is much like that of a small tipulid, but the legs are very much shorter and the wings are differently shaped.

Imago.—Wings broad and short, generally oval in outline, with long and dense surface hairs; entire body and legs with long hairs; antennae with pedunculate joints, each joint with a whorl of hairs, joints 12 to 16 in number; palpi 4-jointed.

HABITS OF LARVAE

The larvae of *Psychoda* are found in cow dung, decaying vegetable matter, exuding sap on tree-trunks, fungi, and in putrid water; those of *Pericoma* are found in shallow slow-flowing water or in tree-holes; *Maurina* has only been recorded from situations where the water had a rather swift flow, and it is evidently adapted to this sort of habitat by the presence of suckers on the ventral surface of the abdomen.

The food of the larvae consists of algae and decaying vegetable matter.

HABITS OF IMAGINES

The imagines may usually be found in large numbers in close proximity to the larval pabulum, and are very common on windows in outhouses or in houses that have damp cellars, or where there are cesspools or cisterns. Rather dark, damp situations are particularly favorable to the species in any stage. The flies may be found in great numbers at lights at night. Many species of *Pericoma* are found upon tree-trunks in the daytime.

The food of the imago consists of nectar or fluid matter in the genera *Pericoma* and *Psychoda,* but the species of *Phlebotomus* are bloodsuckers, feeding upon the blood of various reptiles, amphibians, and mammals—including man. Some species act as vectors of diseases of man, papataci fever and verruga being transmitted by species of *Phlebotomus.* Taylor has described a species from Australia, under the name *Pericoma townsvillensis**, which he records as a bloodsucker. It is not possible to decide as to the generic status of the species, but his figure shows it to be either a *Psychoda* or a *Phlebotomus*—probably it is the latter.

Keys to Genera

LARVAE

1. Ventral abdominal segments with median sucker-like disc; thoracic segments with larger chitinized plates than the following abdominal segments................*Maurina (Pericoma) californiensis.*

---

*Bull. Ent. Research, Vol. 1, Pt. 3, 1915, p. 267.

— Ventral abdominal segments without median sucker-like disc; thoracic segments without chitinized plates, or if these are present they are not noticeably larger than those on the following segments..2

2. Apical abdominal segment short and stout, with 4 small protuberances which are fringed with soft hairs.............*Pericoma**.

— Apical abdominal segment usually conspicuously elongated, in the form of a chitinized tube; apical protuberances and fringes short ....*Psychoda**.

PUPAE

1. Pupa flattened, about twice as long as broad, oval in outline, the abdomen laterally not narrower than the thorax, without spines, apical segment rounded.....*Maurina* (*Pericoma*) *californiensis.*

— Pupa not flattened, more than 3 times as long as greatest breadth, abdomen well differentiated from thorax and with transverse series of spines, apical segment not rounded...*Pericoma* and *Psychoda*†.

MAURINA (PERICOMA) CALIFORNIENSIS Kellogg

Pericoma californiensis Kellogg, Ent. News, Vol. 12, 1901, p. 46. Larva and pupa.
Pericoma californica Kincaid, Ent. News, Vol. 12, 1901, p. 195. Imago.

The above synonymy is the reverse of that given in Aldrich's Catalogue, but must be accepted because of the following facts. It is sufficient for the purpose of identifying a species that either the larval or pupal stage be accurately or recognizably described; Kellogg described and figured both larva and pupa and described the habits of the species in February, whereas the description of the adult by Kincaid did not appear until the following September. The fact that Kellogg gives Kincaid as authority for the name *californica* in the legend to his figures of larva and pupa does not alter the status of *californiensis,* for Kincaid's name, *californica,* had no standing until published by him in September; and that he was in no way responsible for either Kellogg's descriptions or figures seems evident from the absence of acknowledgment to that effect in Kellogg's paper.

---

*The last two genera are separated by the use of characters that appear to apply very well to the groups as far as they are known, but within the composite genus *Psychoda* there are larvae that differ in such degree as to warrant their further subdivision.

†I know of no reliable characters that can be used in the separation of the pupae of *Pericoma* and *Psychoda.* My material is confined to the latter, a key to part of which is given herewith.

The generic name *Maurina* was first used by Müller for a group of 3 species found by him in southern Brazil in situations similar to those in which *californiensis* occurs—rather swift running water*. The larvae agree with the larva of *californiensis* and differ from others belonging to *Pericoma* in having a medio-ventral series of sucker-like discs, one on each abdominal segment except the last, and the pupae, with their oval shape and flat appearance, conform to the same grouping. Eaton has subdivided the genus *Pericoma* into several genera, but upon adult characters only.

I have not seen any stage of *californiensis*, no suitable situations for its occurrence being in this part of the state.

The wing venation of the imago as figured by Kincaid differs from that of the normal *Pericoma*, and in the absence of the base of the anterior branch of the posterior furcate vein resembles that given by Müller for the Brazilian species.

Psychoda Meigen

Keys to Species

larvae

1. Thorax without well-defined chitinized transverse plates.........2
— Thorax with well-defined chitinized plates.........................6
2. Abdomen without chitinized dorsal plates................*minuta*.
— At least sixth and seventh segments with chitinized dorsal plates..3
3. Sixth and seventh abdominal segments each with 3 chitinized transverse dorsal plates.......................................4
— Fifth, sixth, and seventh abdominal segments with chitinized transverse dorsal plates.......................................5
4. Thoracic and abdominal segments, except sixth and seventh, each with a closely approximated pair of hairs on a small circular plate near the posterior lateral margin..................*nocturnala*.
— Thoracic and abdominal segments without such hairs†....*schizura*.
5. Fifth, sixth, and seventh abdominal segments each with 3 chitinized transverse dorsal plates..........................*albimaculata*.
— Fifth and sixth abdominal segments each with 3 chitinized transverse dorsal plates, seventh with 2.....................*floridica*.
6. Prothoracic segment with one chitinized plate, metathoracic segment with 2 such plates; abdominal segments, except 6 and 7, without chitinized plates............................*alternata*.
— Each thoracic and abdominal segment with a chitinized plate on each annulus.................................7

---

*Trans. Ent. Soc. London, 1895, p. 480.

†Neither mentioned in description nor drawn in figures by Fullaway, so assumed to be absent.

7. All chitinized plates with several long and conspicuous bristles; apical respiratory tube short and stout (Pl. XXXIX, Fig. 8) . . . . *superba.*
— Chitinized plates with at most very inconspicuous bristles; apical respiratory tube very distinctly elongated and tapering apically . 8
8. Robust species; basal abdominal segment with narrow transverse chitinized plates . . . . sp. ?
— Slender species; basal abdominal segment with spot-like chitinized plates . . . . *cinerea**.

PUPAE

1. Ventral abdominal segments each with 3 transverse series of spinules, the anterior and posterior marginal series compact, the one on middle of segment consisting of 4 widely separated spinules . . . . *minuta.*
— Ventral abdominal segments each with 2 transverse series of spinules, the widely separated median series and the compact posterior marginal one 2
2. Prothoracic respiratory organs as long as greatest width of thorax; first 2 ventral abdominal segments beyond apex of wings each with 2 spinules in median transverse series . . . . *alternata.*
— Prothoracic respiratory organs much shorter than greatest width of thorax; at least the second ventral abdominal segment beyond apex of wings with 4 spinules in median transverse series 3
3. Prothoracic respiratory organs with groups of openings, not with a continuous series on surface; second dorsal abdominal segment with distinct apical transverse series of spines, the series on segments 3 to 7 with a pair of single long spines close to middle, and another between these and lateral extremity of series, the latter paired (Pl. XXXIX, Fig. 4) . . . . *superba.*
— Prothoracic respiratory organs with continuous series of openings, not groups; abdominal armature not as above 4
4. First ventral abdominal segment beyond apices of wings with 2 spinules in median transverse series . . . . *albimaculata.*
— First ventral abdominal segment beyond apices of wings with 4 spinules in median transverse series . . . . *cinerea.*

PSYCHODA MINUTA Banks

Psychoda minuta Banks, Can. Ent., Vol. 26, 1894, p. 331.

Larva (Pl. XXXIX, Fig. 7).—Length, 2.75–3 mm. Whitish testaceous, apex of anal respiratory tube dark brown.

Head distinctly longer than its greatest width; maxillae prominent, their palpi protruded, fringed; antennae very minute. Pro-

*See remarks in text under *domestica.*

thoracic spiracles slightly elevated; second annulus of segment with indications of a dorsal plate; remaining thoracic and abdominal segments without dorsal plates; divisions between thoracic and abdominal segments distinct, the annuli very poorly defined; surfaces of both thoracic and abdominal segments densely covered with very short pale hairs, the only distinguishable setulose hairs being on lateral margins of posterior annuli of segments. Apical abdominal segment tube-like, chitinized but not conspicuously darker than preceding segments, its length about 3 times as great as its greatest width; apical papillae very small, fringes short (Fig. 9).

Pupa.—Length, 2 mm. Yellowish testaceous.

Prothoracic organ (Pl. XXXIX, Fig. 5) of moderate size, tapering apically, and with a series of small spiracle-like protuberances along one side; eyes large; antennae considerably thickened (male); front view of head and appendages as in Figure 16. Abdominal armature weak; dorsal segments, except basal, each with a transverse posterior series of widely separated spinules and an interrupted median series of very minute setulae (Fig. 17); ventral segments (Fig. 18), except the apical one and those below wings, each with a posterior and anterior transverse series of closely placed spinules and a median transverse series of 4 rather widely placed spinules; apical segment with 3 spines on each side, the two lower ones very closely placed; apical thorns on upper margin strong (Fig. 1).

The above descriptions were drawn from larvae and pupae obtained from cow dung in November, 1915, and April, 1916, the former at Urbana and the latter at White Heath, Ill.

The small size of this species makes it a very difficult one to rear and isolate the stages and exuvia successfully.

Originally described from Sea Cliff, N. Y., and subsequently recorded from Mesilla, N. Mex. Probably of general occurrence throughout North America.

Psychoda superba Banks

Psychoda superba Banks, Can. Ent., Vol. 26, 1894, p. 332.

Larva (Pl. XXXIX, Fig. 13).—Length, 5–5.5 mm. Grayish white; head, chitinized dorsal plates, and apical segment brown.

Dorsal surface of head with several long hairs; antenna terminating in 2 stout bristles and 2 weak hairs (Fig. 12). All thoracic and abdominal segments with a single large chitinized plate on dorsum of each annulus, those of prothoracic and first mesothoracic annuli

narrowly interrupted on middle line; prothoracic spiracle elevated, the protuberance nearly twice as long as thick. Membranous portions of thorax and abdomen covered with numerous very short spinules; chitinized plates on dorsum with a number of long hairs and many short spines (Fig. 8); anterior and posterior annuli of abdominal segments each with long lateral hairs, the median one with a short, stout lateral protuberance which has the appearance of a rudimentary spiracle; ventral segments with a transverse series of long hairs on each of the intermediate (4) and posterior (4–6) annuli, those on the former inserted in small round dark plates; apical segment about 1.5 as long as wide, armed with a number of dorsal and lateral hairs, ventral surface with a large chitinized plate. the rounded apex of which is armed with a fringe of long stiff hairs; laterad of this plate and near its margin is a small rounded plate upon which are 2 long hairs; apex of segment above terminating in 4 short clubbed processes which are fringed with a number of long radiating hairs (Fig. 15).

Pupa (Pl. XXXIX, Fig. 10).—Length, 3.5 mm. Brownish testaceous, not shining.

Prothoracic respiratory organs (Fig. 6) slightly tapering at base and apex, surfaces honeycombed or shagreened and with a number of small tracheal openings. Ventral aspect of pupa as in Figure 10, the transverse abdominal armature in 2 rows on each segment, the anterior row consisting of 4 widely placed spinules on disc and one on each lateral margin, the posterior row of numerous closely placed spinules, the apices of some of which are irregularly dentate; dorsal segments, except basal, each with a single transverse series of spinules on posterior margin which is similar to that on ventral segments, and also, like that series with 4 longer hairs (Fig. 4); apical segment with the upper posterior margin armed with 2 very short thorns, the lower posterior margin with 2 long, curved thorns (Fig. 2).

The foregoing descriptions are drawn from larval and pupal material obtained from water in a tree-hole in the forestry of the University of Illinois at Urbana June 2, 1916. The duration of the pupal stage averaged three days under laboratory conditions.

The species was originally described from imagines obtained at Sea Cliff, N. Y., and has been recorded from Battle Creek, Mich. I took imagines on tree-trunks at Urbana in July and August, 1915.

The larva bears a striking resemblance to that of *Pericoma canescens* Meigen as figured by Miall and Walker*, but differs in the ar-

*Trans. Ent. Soc. London, 1895, Pl. III.

rangement of the hairs both on the dorsal plates and on the ventral surface, and also in the form of the apical segment. There are no outstanding differences in the pupae of the two species.

Psychoda domestica Haseman

Psychoda domestica Haseman, Ent. News, Vol. 19, 1908, p. 282.

The immature stages of this species were described by Haseman. I suspect that the species is a synonym of *cinerea* Banks. The only difference between the larva described by Haseman and that described as *cinerea* in the present paper lies in the absence of the small plates on the basal abdominal segment in *domestica*. These are difficult to see in fresh material, and may have been overlooked by Haseman.

Described from specimens obtained from plant cultures in a laboratory at Columbia, Mo.

Psychoda cinerea Banks

Psychoda cinerea Banks, Can. Ent., Vol. 26, 1894, p. 330.

Larva (Pl. XXXIX, Fig. 11).—Length, 4.75–6 mm. Whitish testaceous, the head, chitinized plates on dorsum, and the apical segment fuscous brown.

Head posteriorly sinuous in outline above, 2 small, narrow, dark plates on the membrane posterior to the central concavity. Thoracic segments each with 2 chitinized dorsal plates; prothoracic annuli each with 2 hairs on each side just in front of the outer half of the plates, these hairs being duplicated in the second annulus, each pair consisting of 2 hairs on a single base; second and third thoracic segments with similar hairs on posterior annuli, the anterior annuli without them; respiratory organ of moderate size, protruded. Basal abdominal segment biannulate, each annulus with a very small dorsal plate; following segments triannulate, the size of the dorsal plates on the anterior segments small, increasing posteriorly until on the last annulus of seventh segment the plate covers one half of the dorsal area; posterior annuli of all segments with a pair of duplicated hairs on each side, the other segments without long hairs; lateral margins of each of the posterior annuli with 2–3 long hairs; apical abdominal segment long and tapering, the terminal appendages small and slender; ventral segments each with a pair of long hairs on each side of the posterior annuli, the discal hairs, especially on middle of annuli, much longer and stronger than on dorsum, their apices bifid or trifid.

Pupa.—Length, 2.5–3.5. Prothoracic respiratory organ very similar to that of *minuta,* the openings of tracheae paired to base; apices of hind tarsi projecting very slightly beyond apices of wings. Armature of abdominal segments similar to that of *superba* but distinctly weaker, especially on apex of second dorsal segment, where the spinules are not well defined; apical segment with both the upper and lower pairs of apical thorns rather strong, the armature as in Figure 3, Plate XXXIX.

The foregoing descriptions are drawn from larvae and pupae which I obtained from a water trough in the dark room of the laboratory here in June, 1916. The pupal stage lasts from 3 to 5 days. The trough is not properly leveled, and along one side a small amount of water periodically accumulates which because of its unfiltered condition is soon permeated with an algal growth, in which the larvae feed.

Haseman's figure of the larva of *domestica* does not show the plates on the second abdominal segment. His description indicates that he found some variation in the number of plates on the basal 3 segments. My material does not show any variation.

Muttkowski's figure of the larva of *cinerea* does not show the dorsal hairs, but probably he overlooked these.

Psychoda albimaculata Welch

Psychoda albimaculata Welch, Ann. Ent. Soc. Amer., Vol. 5, 1912, p. 411.

Full descriptions of the larva, pupa, and imago are given by Welch in the paper above cited.

I have before me the same stages, obtained in the reservoirs at the 35th street pumping-station in Chicago. Welch's material came from the same reservoirs.

Psychoda sp. ?

Larvae of a species closely allied to *domestica* were obtained from a wound in a mulberry-tree, from which sap was exuding, at Urbana in July, 1915. My material is not plentiful enough to permit a definite decision regarding the specific identity of the species. A figure of the larva is given herewith (Pl. XXXIX, Fig. 14).

References to descriptions of immature stages of other North American species are given in the following list of notes and papers, the species dealt with being placed in parentheses in each case

PAPERS DEALING WITH BIOLOGY OF PSYCHODIDAE

Dell, J. A.

'05. Structure and life history of *Psychoda sexpunctata* [*alternata*]. Trans. Ent. Soc. London, 1905: 293–311.

Eaton, A. E.

'95. Supplementary notes on Dr. Fritz Müller's paper on a new form of larva of Psychodidae (Diptera) from Brazil. Trans. Ent. Soc. London, 1895: 489–493.

Fullaway, D. T.

'07. Immature stages of a psychodid fly. Ent. News, 18: 386–389. (*Psychoda schizura.*)

Haseman, L.

'07. A monograph of the North American Psychodidae, including ten new species and an aquatic psychodid from Florida. Trans. Amer. Ent. Soc., 33: 299–333. (*Psychoda floridica.*)

'08. Notes on the Psychodidae. Ent. News, 19: 274–285. (*Psychoda domestica* and *P. nocturnala.*)

'10. The structure and metamorphosis of the alimentary canal of the larva of *Psychoda alternata* Say. Ann. Ent. Soc. Amer., 3: 277–308.

Johnson, J. W. H.

'14. A contribution to the biology of sewage disposal. Jour. Econom. Biol., 9: 105–124, 127–164.

Kellogg, V. L.

'01. An aquatic psychodid. Ent. News, 12: 46–50. [*Pericoma* (*Maurina*) *californiensis.*]

Knab, F.

'13. New moth-flies (Psychodidae) bred from Bromeliaceae and other plants. Proc. U. S. Nat. Mus., 46: 103–106.

Miall, L. C., and Walker, N.

'95. The life history of *Pericoma canescens.** Trans. Ent. Soc. London, 1895: 141–147.

Müller, F.

'95. Contribution towards the history of a new form of larvae of Psychodidae (Diptera) from Brazil. Trans. Ent. Soc. London, 1895: 479–482.

Muttkowski, R. A.

'15. New insect life histories. Bull. Wis. Nat. Hist. Soc., 13 (No. 2): 109.

---

*Deals with a European species, but listed because referred to in this paper.

Osten Sacken, C. R.

'95. Remarks on the homologies and differences between the first stages of *Pericoma* Hal., and those of the new Brazilian species. Trans. Ent. Soc. London, 1895: 483–489.

Welch, P. S.

'12. Observations on the life history of a new species of *Psychoda*. Ann. Ent. Soc. Amer., 5: 411–418. (*Psychoda albimaculata.*)

In addition to the foregoing, there are a number of excellent papers by Haliday, Koch, Zuelzer, Jacobfeurborn, and others, dealing with the larvae and pupae of European species.

Family *BLEPHAROCERIDAE*

FAMILY CHARACTERS

Larva.—Head, thorax, and first and second abdominal segments fused; a slight transverse depression between the anterior margin of first abdominal and the posterior margin of the metathorax; a stout thorn on each lateral margin of one of the fused abdominal segments (second?) as on the other abdominal segments. Dorsal sclerites of head well defined; antenna well developed, slender, with 3 well-differentiated joints; mandibles opposed, strong; maxillary palpi rudimentary. Abdominal segments with very deep lateral constrictions between them, the protruded median portion of segments 3 to 7 each with 1 or 2 stout horns; apical segment rounded, without a horn or with a shorter one than those of the other segments. Sometimes the dorsum has a number of stout thorn-like protuberances in addition to those on lateral margins. Venter with a median longitudinal series of disc-like suckers, usually 6 in number, one on the thoracic complex, and one on each of the succeeding abdominal segments. Laterad of these suckers is a group of filaments which resemble the protruded ventral blood-gills of some species of *Chironomus* and may perform the same function.

Pupa.—Slug-like, ventrally unchitinized and flattened, so that it adheres closely to the rock bottom of the stream, dorsally convex and chitinized, the segments of abdomen distinct, but no noticeable constriction between base of abdomen and apex of thorax, the outline unbroken, oval. Thoracic respiratory organs lamellate, distinctly elevated. Legs extending nearly to apex of abdomen.

Imago.—Tipulid-like, body and legs very long and slender, wings large, with many reticulate creases between the veins, the effect produced being that of a secondary venation.

HABITS OF LARVAE

The larvae of all species are aquatic, living in swift-running streams, and particularly in those that have rocky bottoms—to which they attach themselves by means of the suckers on the ventral surface of their bodies.

The food consists of diatoms, algae, and other small aquatic organisms.

HABITS OF IMAGINES

The imagines are never found except in the vicinity of streams suitable for their larvae. The females are predaceous, feeding upon small insects such as chironomid midges; the males are recorded as feeding on nectar.

Owing to the fact that the larvae require very rapidly flowing pure water as their habitat no species are likely to be found except in mountainous regions, and it is improbable that any occur in Illinois.

BIBIOCEPHALA sp. ?

Larva (Pl. XL, Fig. 1).—Length, 9–10 mm. Pale brown on dorsum, yellowish white on venter; head and chitinized dorsal thorns black.

Antennae elongate, constricted portions of joints whitish, the remainder black; entire dorsum of head chitinized, black; mouth-parts pale. Thoracic segments without thorns; a black triangular chitinized area on dorsum proximad of the first abdominal armature. Last segment of complex and all the abdominal segments except the apical with 4 stout horn-like protuberances on middle of dorsum, a much longer one near each lateral margin, and a pair of them on lateral margin, the upper one, with a shoulder at its middle, directed outward and armed at apex with 2 long hairs, the lower one directed slightly downward; apical segment with a pair of protuberances on dorsum and a number of long hairs on margin of apex of venter. Ventral suckers of moderate size. Lateral ventral blood-gills 5 in number in each group; apical blood-gills stout, 4 in number.

Pupa (Pl. XL, Figs. 2, 4).—Length, 6.5–8 mm. Dark brown.

Thoracic respiratory organs consisting of the usual 4 upright plates (Fig. 6), the length of the outer one being about 1½ times as great as its greatest width. Dorsal surface covered with minute, slightly raised dots; each abdominal segment with a group of larger blackish dots on each side about midway from median line to lateral margin, and between this group and the lateral margin a slight eleva-

tion. Ventral aspect as in Figure 2, the apices of legs not in a straight transverse line. In another specimen—which may be another species or the other sex of the present one—the legs terminate in an almost straight line.

Described from specimens collected in Jenny Creek, Tolland, Col., July 12, 1916 (B. Green).

The larva of this species differs from any other described from North America in the armature of the dorsum. In some species of *Bibiocephala* the larvae have indications of chitinized points, or warts, on the dorsum, but in none are they so well developed as in the present species, the nearest approach being an unnamed Colorado species figured by Kellogg in his revision of the group, Figures 11 and 12 of his paper ('oob).

Prof. T. D. A. Cockerell informs me that the only species recorded from the region where Miss Green obtained the larvae and pupae of the above species is *Bibiocephala grandis* Osten Sacken. It is not improbable that the larvae belong to this species, but on the evidence at hand I do not feel justified in suggesting that they do.

Principal Papers on North American Blepharoceridae

Kellogg, V. L.

'00. Notes on the life-history and structure of *Blepharocera capitata* Loew. Ent. News, 11: 305–318.

'00a. A new blepharocerid. Psyche, 9: 39.

'00b. The net-winged midges (Blepharoceridae) of North America. Proc. Calif. Acad. Sci., ser. 3, Zool., 3: 187–232.

'07. Blepharoceridae. Gen. Ins., Fasc. 56.

Riley, C. V.

'81. Note on Blepharoceridae. Am. Nat., 15: 438–447.

Family *CULICIDAE*

No family of Diptera has received so much attention within the past twenty-five years as the Culicidae. This is due entirely to the fact that they are of very great economic importance, since in addition to their being in most cases a great annoyance to man because of their bloodsucking habits several species are directly instrumental in the transmission of various fevers, and other diseases, prevalent in the warmer parts of the world—such as malaria, yellow fever, and filariasis. The literature on the family is remarkably copious, and as it is generally accessible in America it is not the purpose of the writer

to give an extended review of the species here, the principal divisions being indicated only. Students who may desire a fuller knowledge of the family characters should consult the papers listed herewith.

I have retained Dixidae as a distinct family, contrary to the opinion of some writers who consider that the group should be ranked as a subfamily of Culicidae.

FAMILY CHARACTERS

Larva.—Head large, complete, exposed; mandibles moving horizontally; antennae well developed; mouth-brushes present (Culicinae) or absent (Corethrinae, pt.). Thoracic segments fused, appearing as a complex mass. Respiration carried on by means of posterior spiracles which open on last segment, their tips frequently in the form of elongated tubes, by means of which the larvae obtain a direct connection with the air by piercing the surface film of the water in which they live. In some of the Corethrinae there are present in the thorax and in the apex of the abdomen a pair of air-sacs which are usually black and conspicuous, contrasting with the glassy appearance of the larval body. These species do not keep a connection with the air, and are frequently found at great depths in lakes. Body with more or less conspicuous hairs or hair tufts.

Pupa.—As in the larvae, the thorax is conspicuously swollen; the respiratory organs are placed well back on the sides of the disc of the thorax—a characteristic that distinguishes the family from the Chironomidae. The abdomen has conspicuous hairs, some of those on the dorsum being stellate, and its apex is usually armed with 2 or 4 large, flat, paddle-like organs.

Imago.—Readily distinguished by the tomentose or scaled wings, slender build, long legs, complete marginal wing-vein; and by the absence of ocelli, of discal cell of wing, and of the v-shaped dorsal thoracic suture.

HABITS OF LARVAE

The larvae are aquatic, living under a variety of conditions, some of them in very deep water in lakes, some in shallow permanent pools, others in ditches that offer a permanent breeding-place or in water in depressions or receptacles that are of a temporary nature. The food of the species differs considerably, some of them being almost entirely vegetarian in habit, feeding on decaying detritus in the water or upon algae, while others are predaceous, feeding upon insect larvae and other small animals.

HABITS OF IMAGINES

The female imagines of the Culicinae are almost entirely bloodsuckers though some are found also upon flowers. Some species are the only known vectors of certain diseases, such as malaria, yellow fever, and filariasis. On account of this latter fact a very voluminous literature has appeared within the last twenty years, a brief list of some of the more recent and important works being given at the end of this summary of the family.

Keys to Subfamilies

LARVAE

1. Apex of abdomen with a long respiratory tube..................2
— Apex of abdomen without elongate respiratory tube.............3
2. Antennae pendulous, hanging down in front of head and armed with 4 long and strong apical bristles (Pl. XLI, Fig. 1), or when at rest folded back against sides of head and armed with 2 or 3 strong apical claws..........................Corethrinae, pt.
— Antennae porrect, not pendulous nor folded back against sides of head when at rest, and usually with a few weak bristles and one or two pointed processes (Pl. XL, Fig. 3)........Culicinae, pt.
3. Anal segment cylindrical; last segment with a flat dorsal area in which are 2 spiracles; thorax and abdomen without black air-sacs ....Culicinae, pt.
— Anal segment either bladder-like or the last segment with no spiracles and the larva transparent, glass-like; a pair of black air-sacs in thorax and another in seventh abdominal segment (Pl. XLI, Fig. 2)..............................Corethrinae, pt.

PUPAE

1. Apical abdominal appendages acutely pointed....Corethrinae, pt.
— Apical abdominal appendages rounded.........................2
2. Thoracic respiratory organs elongate-oval, pointed at apex, black, contrasting sharply with color of thorax.......Corethrinae, pt.
— Thoracic respiratory organs more or less trumpet-shaped, never elongate-oval or pointed at apex, generally but little darker than thorax (Pl. XL, Fig. 8).............................Culicinae.

IMAGINES

1. Proboscis short, not adapted for piercing...........Corethrinae.
— Proboscis very long, adapted for piercing.............Culicinae.

Some of the more Important Works on North American Culicidae

Felt, E. P., and Young, D. B.
'94. The mosquitoes or Culicidae of New York State. Bull. 79, N. Y. State Mus.

Howard, L. O.
'00. Notes on the mosquitoes of the United States. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. ser.
'10. Preventive and remedial work against mosquitoes. U. S. Dept. Agr., Bur. Ent., Bull. 88.

Howard, L. O., Dyar, H. G., and Knab, F.
'12. The Mosquitoes of North and Central America and the West Indies. (In 4 volumes, one of which is yet to appear.)

Johannsen, O. A.
'03. Aquatic Nematocerous Diptera. Bull. 68, Pt. 6. N. Y. State Mus., pp. 388–429. (Part of a comprehensive report, by various authors, on the aquatic insects of New York State.)

Family *DIXIDAE*

This is a small family, containing but one genus and about a score of described species. Some authors have considered them as forming a subfamily of Tipulidae, while others have placed them in the Culicidae. I am of the opinion that they are entitled to family rank, and so treat them in the present paper.

FAMILY CHARACTERS

Larva (Pl. XL, Fig. 5).—Head complete, not retractile, antennae and maxillary palpi long and slender, mandibles opposed, stout; maxillae with a fringed lobe homologous with that of Simuliidae (Pl. XLI, Fig. 5); labium chitinized, densely hairy (Pl. XLI, Fig. 3). Thoracic segments distinct, similar in form to those of abdomen, the first 2 armed on anterior margin of dorsum with several long hairs. First and second abdominal segments each with a pair of pseudopods on dorsum, the apices of which are armed with curved spines; dorsum of segments 5, 6, and 7 each with a transverse pair of slight elevations which are armed with closely placed spines, or the segments with a transverse band of spines posteriorly; ventral surface of some of the abdominal segments usually with flattened areas which are armed on their margins with spines; preapical segment with a pair, or more, of long hairs; apical segment terminating above in a chitin-

ized tube-like process, which is armed with a number of long hairs, and ending below in a pair of slightly pointed processes which are fringed with closely placed hairs.

Pupa (Pl. XL, Fig. 7).—Antennae extending to or beyond middle of wings; palpi forming a semicircle, their apices incurved in front of clypeus; eyes rather small. Thoracic respiratory organs elevated, funnel-shaped; legs recurved against base of abdomen. Abdomen with 3 rather distinct sharp ridges on each segment, the apices of which are slightly serrate; apical segment terminating in 2 long, pointed processes; apical half of abdomen directed cephalad because of the curvature of the body, thus closely resembling the pupae of Culicidae.

Imago.—See key to imagines of Nematocera.

HABITS OF LARVAE

The larvae are aquatic, living in shallow wells, and in clear water such as is found in springs and slow-flowing mountain streams. The food consists of algae.

HABITS OF IMAGINES

The imagines occur in the vicinity of streams and may be swept from grasses or other vegetation overhanging the water. I have found them very commonly among grasses on almost perpendicular rocks that were continuously wet owing to water dripping over their surface. They have poorly developed mouth-parts, but I have found them on flowers, evidently feeding on nectar.

I have before me examples of the larvae and pupae, some of which were obtained by Mr. Hart at Havana, Ill., and others by Dr. S. A. Forbes in Yellowstone National Park. They differ from the species described by Johannsen in the armature of the abdomen and the structure of the apical segment, and in a few other particulars.

Paper containing Account of North American Dixidae

Johannsen, O. A.
'03. Aquatic Nematocerous Diptera. Bull. 68, Pt. 6, N. Y. State Mus., pp. 429–432.

Superfamily *Chironomoidea*

This superfamily contains 3 families, Chironomidae, Ceratopogonidae, and Orphnephilidae.

The position of the last-named family has been somewhat in dispute amongst taxonomists, but the larval and pupal characters undoubtedly ally it more closely with Chironomidae than with any other family.

SUPERFAMILY CHARACTERS

Larva.—Head complete; antennae elongate, except in some Ceratopogonidae, retractile in Tanypinae; labial plate flat, usually notched anteriorly. Thorax and abdomen with distinct segments, 12 in number; pseudopods present upon prothorax and apical abdominal segments, on prothorax only, or entirely absent; respiration carried on by means of lateral prothoracic, abdominal, and anal spiracles, or by apical spiracles and anal blood-gills, or by the latter alone. Sometimes the anal blood-gills are permanently exserted and located on the latero-ventral margins of the apical segment, but usually they are entirely or partly retractile, or they are situated at apex of last segment and are somewhat leaf-like and not retractile.

Pupa.—Head without chitinized protuberances; antennae curved over eyes. Thoracic respiratory organs elevated, usually in the form of a single tube, and not uncommonly filamented, rarely sessile. Legs in Chironomidae recurved against base of venter of abdomen and apex of thorax; in the other families straight and not at all, or but slightly, exceeding length of wings. Abdomen in Chironomidae and Orphnephilidae with or without weak dorsal setulae, in Ceratopogonidae with leaf-like or thorn-like bristles; apical segment in Chironomidae usually with 2 or 4 pointed thorn-like protuberances.

Imago.—Antennae consisting of 6 to 15 joints; palpi 2- to 5-jointed, pendulous; proboscis in Chironomidae and Orphnephilidae poorly developed, in Ceratopogonidae well developed and chitinized. For synoptic characters see key to imagines on a previous page.

Family *CERATOPOGONIDAE*

After a careful examination of all the stages of this group and a comparison of these with the various stages of other families of the suborder I have decided to separate it, as a family, from Chironomidae, in which it has been previously placed as a subfamily.

FAMILY CHARACTERS

Larva.—Head complete (Pl. XLI, Fig. 15); mandibles (Pl. XLI, Figs. 13, 14) opposed, toothed or simple and hook-like; labium dis-

tinct; antennae small (Pl. XLI, Fig. 11). Respiration carried on by means of posterior spiracles or apical abdominal protrusive blood-gills; in the terrestrial forms I am unable to find lateral abdominal spiracles. Abdomen in aquatic forms worm-like, without pseudopods (Pl. XLII, Fig. 6), the only hairs present confined to apex of last segment; abdomen in terrestrial and semiaquatic forms with numerous bristles (Pl. XLII, Figs. 1, 2, 3, 4), the truly terrestrial species with distinct prothoracic and anal pseudopods, and some of the bristles on body leaf-like or lanceolate (Pl. XLI, Figs. 6, 7, 8, 9, 10).

Pupa (Pl. XLII, Fig. 5).—Head without thorns. Thorax compact, the wings and legs fused together and to thorax; apices of legs not, or but slightly, exceeding apices of wings, not recurved; thoracic respiratory organs elongate; disc of thorax in terrestrial forms with a number of long bristles. Abdomen with bristles or leaf-like protuberances; apical segment terminating in 2 or 4 thorns.

Imago.—Antennae in both sexes consisting of 15 joints, the apical 3, 4, or 5 usually noticeably longer than the others; male antennae plumose, that of female short-haired; mouth parts chitinized, fitted for piercing. Thorax not much arched, not overhanging head. Wings short; venation similar to that of *Chironomus*. Legs stout, the fore and mid pairs shorter than the hind pairs.

HABITS OF LARVAE

The larvae of *Forcipomyia* are terrestrial, feeding on cow dung, under bark of trees, and in decaying vegetation, and rarely they are found under decaying drift on the margins of rivers. The larvae of *Ceratopogon* occur on decaying wood in water, usually on submerged logs; those of *Culicoides* are also aquatic, occurring in tree-holes and in streams; while a species of *Pseudoculicoides* is found in exuding tree-sap. All species of other genera known to me are truly aquatic.

HABITS OF IMAGINES

The species of *Culicoides* are the well-known "punkies" and are invariably bloodsuckers. *Pseudoculicoides* is also a blood-sucking genus. I have no record of this habit for any of the other genera in so far as man and domestic animals are concerned, but they attack insects, attaching themselves to the body and wings.

Keys to Genera

LARVAE

1. Pseudopods present on prothorax and apical abdominal segment . . 2
— Pseudopods absent, body worm-like (Pl. XLII, Fig. 6) . . . . *Pseudoculicoides, Culicoides, Palpomyia,* etc.
2. Body circular in cross-section, armed with long bristles, some of which are leaf-like (Pl. XLII, Figs. 1, 2, 3) . . . . *Forcipomyia.*
— Body flattened, oval in cross-section, armed with short simple bristles (Pl. XLII, Fig. 4) . . . . *Ceratopogon.*

PUPAE

1. Thorax without long bristles 2
— Thorax with long bristles 3
2. Thorax with short, pointed protuberances . . . . *Culicoides.*
— Thorax without distinct protuberances, at most with slight elevations (Pl. XLII, Fig. 5) . . . . *Palpomyia,* etc.
3. Second abdominal segment with 4 bristles . . . . *Ceratopogon.*
— Second abdominal segment with about 10 bristles . . . . . . *Forcipomyia.*

IMAGINES

1. Wings with distinct hairs on disc, either in the form of short upright microscopic setulae or broad decumbent scales 2
— Wings without hairs on disc, rarely with a few near apex of costal margin 6
2. Thorax with a distinct slit-like or circular depression on each side of disc slightly caudad of the inner angle of prothorax . . . . *Culicoides.*
— Thorax without these depressions 3
3. Wings densely hairy, decumbent scale-like hairs present on whole surface 4
— Wings with upright hairs which are usually absent on anal angle, no scale-like hairs present 5
4. Basal joint of hind tarsi shorter than, or at most as long as, second . . . . *Forcipomyia.*
— Basal joint of hind tarsi very much longer than second . . . . *Euforcipomyia.*
5. Empodia absent; first and third veins of wings fused; tarsal claws of female very unequal in length . . . . *Neoceratopogon.*
— Empodia present; first and third veins of wings connected by a cross-vein; tarsal claws of female equal . . . . *Ceratopogon.*
6. First and third vein connected by a cross-vein or fused basally . . . 7
— First and third veins disconnected for their entire length 11
7. At least one pair of femora with distinct ventral spines 8

— Femora without ventral spines............................10
8. Generally more than one pair of femora with spines; neither fore nor hind femora noticeably thickened..............*Palpomyia.*
— Only fore or hind femora with spines, the spinose pair perceptibly thickened...9
9. Fore femora thickened and spinose..................*Heteromyia.*
— Hind femora much thickened and spinose............*Serromyia.*
10. Media sessile...................................*Johannsenomyia.*
— Media petiolate.................................*Hartomyia.*
11. At least one pair of femora with ventral spines................12
— Femora not spinose...13
12. Media sessile...*Bezzia.*
— Media petiolate...............................*Pseudobezzia.*
13. Media sessile......................................*Probezzia.*
— Media petiolate.................................*Parabezzia.*

N. B. The genus *Atrichopogon* is distinguished by the bare wings and distinct empodia. I have no species belonging to this genus.

When I wrote my paper on the Chironomidae of Illinois, in which I included the present family as a subfamily of Chironomidae, I had obtained data upon and materials representing the early stages of but one species of *Culicoides.* In 1916 I succeeded in obtaining a pupa of another species in the Sangamon River, and the larvae and pupae of one from water which had collected in a hollow tree-stump in the forestry of the University of Illinois, at Urbana. These discoveries prove that the genus is truly aquatic, as stated in my previous paper, and ought to dispel the doubts of the fact that have been expressed by some dipterologists. I was also successful in obtaining the larvae and pupae of a species of *Pseudoculicoides* from a wound on the trunk of an elm tree on the university campus. The sap was flowing freely from the wound, and associated with this species were many larvae of *Mycetobia divergens,* which superficially resemble those of *Pseudoculicoides.* The larvae of *Culicoides* and *Pseudoculicoides* are very similar to those of *Palpomyia.* The characters distinguishing them will be dealt with in a future paper—provided I can command the time necessary for the study.

Family *CHIRONOMIDAE*

In this paper I have included in this family only two subfamilies, Tanypinae and Chironominae.

FAMILY CHARACTERS

Larva.—Head complete; mandibles opposed, toothed; antennae elongate; labial plate dentate anteriorly. Thoracic segments distinct, rarely slightly swollen in Tanypinae; prothoracic pseudopods present, usually fused to or nearly to apex, and of moderate length, rarely very short, always armed at apices with hairs or bristles. Abdomen consisting of 8–9 segments; apical segment in aquatic species with a dorsal pair of papillae, upon which are several long hairs, and usually 2 or 4 small non-retractile blood-gills caudad of these and between the bases of the posterior pseudopods, the apical claws of the latter normally retractile, ventral blood-gills sometimes present; apical segment in terrestrial forms without dorsal papillae, with small pseudopods, the blood-gills small and wholly or partly retractile; larvae peripneustic, at least with minute lateral abdominal spiracles which may not function, or metapneustic, respiration being carried on by means of the anal papillae and blood-gills; body without strong hairs or bristles, sometimes with numerous soft hairs.

Pupa.—Antennae elongate, curved over upper margin of eyes; head without spines, occasionally with a pair of conical tubercles at base of antennae. Thoracic respiratory organs usually elongate, rarely sessile, located near anterior margin of thorax; wings extending slightly beyond base of abdomen; legs elongate but recurved against venter so that they project but little if any beyond apices of wings. Abdomen circular or oval in cross-section, either without long hairs or prominent bristles or the former confined to the lateral margins and strap-like, and the bristles small and located on disc of segments or at their apices; apical segment with 2 more or less flattened, fin-shaped appendages.

Imago.—A great majority of the species resemble mosquitoes in their general build. The costa is, however, not continued round the entire wing; there are no scale-like hairs on the wings; and the mouth-parts are not constructed for piercing, being usually poorly developed.

HABITS OF LARVAE

By far the greater number of the species are aquatic in the larval and pupal stages, only a few of the more specialized species in Chironominae being terrestrial. The food of the aquatic forms consists of algae, decaying vegetable matter, diatoms, and small Crustacea. The terrestrial forms known to me occur in manure and decaying vegetable matter.

HABITS OF IMAGINES

The imagines are found in great numbers in the vicinity of lakes, ponds, rivers, or other bodies of water. They are particularly numerous at lights at night. Many of the species do not appear to feed in this stage, but some are found on flowers, evidently partaking of the nectar or feeding on the pollen, and I have seen one species feed upon moist fly-specks on a store-window at night.

For a further discussion of the habits of this family see my paper on the Illinois species listed at the end of this summary.

Keys to Subfamilies

LARVAE

1. Antennae retractile; labium with 4 to 7 teeth, reversible internally; thoracic segments usually more or less dilated....... Tanypinae.
— Antennae not retractile; labium usually with more than 7 teeth, not reversible; abdominal thoracic segments not dilated............ .... Chironominae.

PUPAE

1. Thorax much distended, the head much below upper level thereof; thoracic respiratory organs simple, egg- or cornucopia-shaped; abdominal segments without strong dorsal spinules; apical processes flat, sometimes rounded at apices and with a few strap-like hairs on margins............................ Tanypinae.
— Thorax not much distended, the head not much below the upper level thereof; thoracic respiratory organs branched, often with many thread-like filaments, or if simple the abdomen has usually dorsal spinules and the apical segment has the pair of processes pointed.................................... Chironominae.

IMAGINES

1. Medio-cubital cross-vein present; wings frequently hairy; antennae in both sexes with 15 joints; male hypopygium with each side consisting of a short basal piece and an apical slender process which is usually curved and acute at tip.................. Tanypinae.
— Medio-cubital cross-vein absent, or if present the antenna of the female has only 8 joints and the hypopygium of the male has in addition to the 2 pieces present in Tanypinae another piece projecting along the inner side of the basal portion which bears a fringe of long hairs; antenna of male 15-jointed, occasionally with fewer joints, that of female 8-jointed................. Chironominae.

Subfamily TANYPINAE

SUBFAMILY CHARACTERS

Larva (Pl. XLIII, Fig. 1).—Head usually much more elongate than in Chironominae (Pl. XLIII, Figs. 7,8); antennae long and slender, retractile; palpi longer than their diameter; labial plate hinged, retractile by turning upon its base, the anterior margin being thus frequently found directed inward and backward in preserved specimens, form of plate spatulate, armed with 4 to 7 teeth. Thoracic segments more or less swollen and differentiated from the abdominals; prothoracic pseudopods well developed. Abdomen slender, often armed with soft hairs which it is very difficult to see; anal pseudopods sometimes very long; dorsal papillae distinct, armed with a number of long hairs; apical blood-gills 4 in number.

Pupa (Pl. XLIII, Fig. 3).—Thorax much more distinctly swollen than in Chironominae, the respiratory organs always simple, not conspicuously fringed, frequently egg-shaped (Fig. 10) or trumpet-shaped. Legs and wings rather short, the former recurved against venter. Abdomen without noticeable dorsal armature; lateral margins with a few long strap-like hairs; apical appendages flattened, their margins with several long strap-like hairs, and sometimes with a short fringe.

Imago.—See key to subfamilies.

Subfamily CHIRONOMINAE

This subfamily contains many more genera than does Tanypinae, and among them are some of the commonest of the Nematocera.

SUBFAMILY CHARACTERS

Larva.—Readily distinguished from larvae of Tanypinae by their stout, non-retractile antennae and the flat, exposed, fixed labial plate. The blood-red color of some of the larvae of *Chironomus* has earned for them the popular name of "blood-worms".

Pupa.—The pupae of all species of *Chironomus* known to me have the thoracic respiratory organs divided into many thread-like filaments, and are separated by this character from every other nematocerous family. The species that have these organs pedunculate more nearly resemble the pupae of Tanypinae, but the latter are generally more culicid-like, having the thorax more swollen and the abdomen

curved forward ventrally, while the Chironominae are almost invariably straight.

Imago.—See key to subfamilies.

Keys to Genera

larvae*

1. Two or four permanently exserted blood-gills present on the penultimate abdominal segment (Pl. XLIII, Fig. 5) . . *Chironomus,* pt.
— No permanently exserted blood-gills present on penultimate abdominal segment. 2
2. Prothoracic pseudopods poorly developed (Pl. XLI, Fig. 17) ; anal pseudopods fused, in the form of a single sessile disc whose margins are furnished with small hooks (Pl. XLI, Fig. 12) ; anal dorsal papillae absent; terrestrial species (Pl. XLI, Fig. 16) . . . . *Camptocladius.*
— Prothoracic and anal pseudopods well developed, not sessile; anal dorsal papillae usually present and furnished with several apical hairs 3
3. Abdominal segments each with a distinct pencil of hairs on each side . . . . *Cricotopus,* pt.
— Abdominal segments without pencil of hairs on either side 4
4. Labium consisting of a pale rounded central piece and a digitate, dark, heavily chitinized piece on each side . . . . . . *Chironomus,* pt.
— Labium not as above, the lateral margins continuous, and not in the form of separate digitate plates 5
5. Color of living larva blood-red; antennae short, not half as long as head, maxillary palpi long . . . . *Chironomus,* pt.
— Color of living larva green or yellowish, rarely faintly reddish 6
6. Larva living within a case one end of which has a number of slender tentacular protuberances (Pl. XLIII, Fig. 9) . . . . *Tanytarsus.*
— Larva free, or if enclosed the case is not as above but more in the form of a rough tunnel-way, and there are no protuberances on either end 7
7. Dorsal papillae on apical segment much longer than their diameter . . . . *Metriocnemus.*
— Dorsal papillae on apical segment about as long as their diameter . 8
8. Antennae much more than half as long as head 9
— Antennae not more than half as long as head 10
9. Very small species, not more than 2.5 mm. in length; only 2 permanently exserted blood-gills at apex of abdomen . . . . . *Corynoneura.*
— Larger species, usually more than 5 mm. in length; 4 permanently exserted blood-gills at apex of abdomen . . . . *Tanytarsus.*

---

*Specific identifications may be reached by using the keys to larvae and pupae in my paper on this family listed at the end of this portion of the present paper.

10. Maxillary palpi usually noticeably longer than their diameter; anterior margin of labium transverse or slightly convex, the sides not sloping abruptly away from the central portion (Pl. XLIII, Fig. 4) 11
— Maxillary palpi usually about as long as their diameter; anterior margin of labium usually centrally transverse, the sides sloping abruptly backward from the central portion (Pl. XLIII, Fig. 2). .... { *Orthocladius*, pt. *Cricotopus*.
11. All labial teeth rounded or all acute .... *Chironomus*, pt.
— Central labial tooth rounded, broader than laterals, which are very acute .... *Diamesa*.

PUPAE

1. Thoracic respiratory organs consisting of numerous long hair-like filaments .... *Chironomus*.
— Thoracic respiratory organs stalk-like, sometimes furnished with a few surface filaments; or sessile 2
2. Abdominal segments in part with paired spot-like groups of conspicuous black spinules which are visible to the naked eye .... *Tanytarsus*.
— Abdominal segments without distinct spot-like groups of black spinules, the surface either bare or with much less conspicuous armature which is distributed over a large area of each segment and is only visible under a strong lens 3
3. Thoracic respiratory organs sessile 4
— Thoracic respiratory organs stalk-like 7
4. Abdominal segments without stout teeth on their posterior margins, and otherwise unarmed .... *Camptocladius*.
— Abdominal segments, except basal and apical, with stout teeth on their posterior margins, or with setae on dorsum 5
5. Setulae confined to disc of segments, no postmarginal teeth or spines present .... *Thalassomyia*.
— Short teeth or spines present on posterior margins of some of the abdominal segments 6
6. Disc of dorsal segments with a band of distinct setulae; apical appendages without long hairs .... *Metriocnemus*, pt.
— Disc of dorsal segments without a band of distinct setulae; apical appendages each with 3 long hairs .... *Diamesa*.
7. Abdominal segments, except basal and apical, each with a conspicuous postmarginal series of strong spinules 8
— Abdominal segments, except second, without a conspicuous postmarginal series of strong spinules .... { *Orthocladius*, pt. *Cricotopus*.

8. Apical abdominal appendages each with 3 long terminal hairs..... ....*Metriocnemus*, pt.
— Apical abdominal appendages each with 2 short and inconspicuous hairs before apices.........................*Orthocladius*, pt.

Important Papers on North American Chironomoidea*

Johannsen, O. A.
'05. Aquatic Nematocerous Diptera. II. Bull. N. Y. State Mus., No. 86:76–315. (This paper contains descriptions of all species of Tanypinae and Chironominae that had appeared in North America up to the time of its publication, and a very full bibliography of the superfamily Chironomoidea.)
'08. New North American Chironomidae. Bull. N. Y. State Mus., No. 124:264–285. (Contains a few keys to genera and species supplementary to those of the previous paper, and also a small additional bibliography.)

Malloch, J. R.
'15. The Chironomidae or midges of Illinois, with particular reference to the species occurring in the Illinois River. Bull. Ill. State Lab. Nat. Hist., Art. VI, 10:275–543. (Contains keys to genera and recognizably described species of North American Ceratopogonidae, and keys to larvae and pupae of some Chironomoidea.
'15. Some additional records of Chironomidae for Illinois and notes on other Illinois Diptera. Bull. Ill. State Lab. Nat. Hist., Art. IV, 11:305–363. (Contains descriptions of some genera and species not included in the previous paper, and notes on habits.)

Family *ORPHNEPHILIDAE*

I have not seen the larva or pupa of this family. There are but two genera in the family, *Orphnephila,* containing three species, and *Androprosopa*, with two. Only one species of *Orphnephila* is recorded as occurring in North America, the other genus being entirely unrepresented here as far as we know at present. The following generalizations for larval and pupal stages are taken from Thienemann's descriptions of the immature stages of *Orphnephila testacea* Ruthé, a European species occurring in the United States.

Because of my failure to obtain the early stages of this family I have not included it in my keys to the larvae and pupae of Nematocera.

*As previous authors have included in Chironomidae all the families I have now put in Chironomoidea I have listed papers dealing ostensibly with the Chironomidae under the superfamily, in accordance with the arrangement of the present paper.

FAMILY CHARACTERS

Larva.—General appearance as in Chironominae, the prothoracic and anal pseudopods, anal dorsal papillae, and paired apical dorsal blood-gills being as in that subfamily. Details of the structure of the head are lacking in Thienemann's description, but his figure shows that the shape of the head more closely resembles that of *Forcipomyia* than that of *Chironomus*, the mouth opening ventred instead of on the anterior face. The prothoracic spiracles resemble small warts. The thoracic and abdominal segments are longer than broad, clearly differentiated, and armed with numerous spinules. The prothoracic and anal pseudopods are armed at the apices with curved spines as in Chironomidae.

Pupa.—The pupa is distinguished from pupae of Chironomidae by the stout, short thoracic respiratory organs, which are covered with minute warts, by the presence of small warts on almost the entire body surface, and by the structure of the apical segment, which has at the tip 2 rather long, slender, upwardly directed processes and 2 long slender hairs.

Imago.—See key to imagines of Nematocera.

HABITS OF LARVAE

The larvae are found in swift-flowing streams, and have the same food habits as those of Chironomidae.

HABITS OF IMAGINES

The imagines are very sluggish in habit and are rarely taken on the wing. Nearly all the specimens that I have taken in Britain, where *Orphnephila testacea* occurs commonly, were swept from grasses and ferns on the overhanging banks of mountain streams. This species occurs very rarely in this country.

Tribe Oligoneura

I have included in this tribe the superfamilies Cecidomyioidea and Bibionoidea, while Brauer included only the former. The arrangement may not be an ideal one, and probably some may consider the superfamilies as belonging to separate tribes; but to my mind they have many characters that link them together, though not so closely as is the case with the families in Polyneura. If, however, they must be separated, I would associate neither of the groups with any

other tribe, but Bibionoidea should constitute a new tribe and Cecidomyioidea remain as the only superfamily in Oligoneura.

CHARACTERS OF THE TRIBE

Larva.—In some respects the larvae of Cecidomyioidea are very primitive; in fact, if we consider their respiratory system—which is almost without exception functionally peripneustic—and the number of segments (13) as of primary importance we must place these insects with the most generalized of the Diptera. But, probably owing to the mode of life of the larvae, the head has undergone considerable transformation, until, with the absence or vestigial nature of the mandibles and the almost invariable reduction of the head-capsule posteriorly, we have what is undoubtedly a much specialized form. The much reduced heads of these larvae separate them readily from other Nematocera.

The Bibionoidea differ from the foregoing in having the head-capsule complete and the mandibles developed; and in that all the species known in the larval stage have lateral abdominal spiracles—some functional and others not. The species of *Bibio* known to me have apparently 13 segments in addition to the head, and 8 pairs of lateral spiracles in addition to the prothoracic and anal pairs—characters which indicate that they are very primitive. The aquatic forms (Simuliidae) have peculiarly modified mouth-parts, and because of their living in running water show adaptations in other respects. The Bibionidae and Scatopsidae are terrestrial, and while the lateral abdominal spiracles are present, I believe that in some cases they are doubtfully functional.

Pupa.—The pupae of both superfamilies are structurally primitive. The head in the species of Cecidomyiidae that live in galls is armed with sharp chitinized thorns by means of which the pupa bores its way to the surface prior to the emergence of the imago. The other members of the tribe possess no cephalic thorns. The thoracic respiratory organs are sessile in most species, being elongated only in Scatopsidae, Simuliidae, and a few Cecidomyiidae. For other characters see synoptic keys and descriptions of families.

Imago.—See synoptic key to the imagines of Nematocera.

Superfamily *Cecidomyioidea*

But one family is referable to this superfamily. It is of considerable extent, world-wide distribution, and of much economic importance.

Family *CECIDOMYIIDAE*

I have not devoted much time to rearing this family, and my material is limited, consisting of a few species that were picked up in the course of other work, those that form the existing collection of this Laboratory, and a number that were kindly supplied by Dr. E. P. Felt. Judging from my examination of this material, there appear to be quite a number of good distinguishing characters for both larvae and pupae. Owing to the very large number of species included in the family it would require a great amount of work and the expenditure of much time to devise a satisfactory classification of the early stages. I have figured a few details of some of the larvae and pupae as indices of the general character of these stages. Kieffer, in "Genera Insectorum"*, has given, in addition to generic synopses of imagines, a summary of the larval and pupal characters of the family, and keys to the known larvae of the European genera. These keys will no doubt prove serviceable to students of the North American species.

Dr. E. P. Felt has been for several years studying this family, and his work on the imagines has done more to clear up this obscure group than that of any other worker either in America or abroad.

CHARACTERS OF THE FAMILY

Larva.—The head is not so heavily chitinized as in other families of the Nematocera, and on that account, and because it is generally incomplete posteriorly and very small, it is rather difficult to distinguish details, especially in the small species; the eyes and mandibles are apparently absent, but the antennae are long and 2- or 3-jointed. The presence of 13 segments, exclusive of the head and of lateral abdominal spiracles, is sufficient to distinguish the larvae of this family from any other in the order except Bibionidae, and here the complete head of the latter serves to distinguish the two families. Normally there is present also, at least in the mature larvae, a chitinized plate under the membrane on the ventral surface of the second thoracic segment. This plate differs considerably in the different species, and its form is of value for identification purposes. It serves the larvae as a means of propulsion in making their leaps after leaving their pabulum to pupate, or when they are removed therefrom and placed upon a dry surface. Many species form galls upon plants, and may be identified by these alone, as each species usually attacks but

*Fasc. 152. (1913)

one plant species, or a few closely allied plants, and the resultant gall is characteristic of the insect. Certain species that live in resin of trees have the lateral abdominal spiracles vestigial and the apical pair very much enlarged.

Pupa.—It is not a simple matter to indicate characters by means of which the pupae of this family may be distinguished from those of allied families because there are within its limits species that differ greatly in their larval habits, some living in hard, woody galls, and others in decaying fungi, manure, mines in leaves, or under bark, the nature of the material in which the pupa is found having a considerable influence upon the structure of the head. I have found it true in other groups that when the species have in the pupal stage to force their way through either hard earth, wood, or the enclosing cocoons of some host, the head-capsule of the pupae is armed with a number of sharp thorns well suited to the purpose of boring a way out so that the imago may be able to emerge. On the other hand, species that either do not penetrate deep into soil or wood, that are aquatic, or normally frequent moist ground, do not have cephalic thorns. From my limited data this rule appears to hold good in the Cecidomyiidae, the species that must bore their way out of galls having the head armed with sharp thorns, while those that are found in fungi, manure, or decaying wood have no such armature. According to my present data, the presence of cephalic thorns may be depended upon to separate the species possessing them from other Nematocera, no other family of which has such thorns, but the species without such thorns are difficult to separate from those of Sciaridae. The comparative sizes of the first and second tarsal joints of Cecidomyiidae serve to separate the pupae of most of this family from those of Sciaridae, the basal one being much shorter than the second in the former while in the latter it is distinctly longer.

Imago.—The antennae differ considerably in the number of their segments, ranging from 16 to 30 in different genera, and not infrequently differing in the sexes of the same species. Usually the antennal segmentation is very distinct, the segments being often nodose, or even binodose, and armed with whorls of long hairs. In Cecidomyiinae looped hairs which have no free end are present on the antennae, being undoubtedly sense organs. The legs are usually long and slender, and in some groups the basal joint of the tarsi is very much shorter than the second. The wings are characterized by the small number of the longitudinal veins, and the absence of cross-veins except near base; the surface is usually pubescent or covered with depressed, scale-like hairs.

Kieffer bases separation of the larvae of Cecidomyiinae from those of Lestremiinae and Heteropezinae on the situation of the anal opening, which in the former is on the ventral surface of the apical segment, while in the other two subfamilies it is situated at the extremity of that segment. No character for the separation of Lestremiinae and Heteropezinae is given in his subfamily key, nor are there any tangible distinctions mentioned in his discussion of the larvae of these subfamilies. No attempt has been made, to my knowledge, by any writer to designate characters for the separation of the pupae of the different subfamilies.

Retinodiplosis pini-inops Osten Sacken

Cecidomyia pini-inops Osten Sacken, Stett. Ent. Zeit., 1861, p. 418.

Retinodiplosis pini-inops (Osten Sacken) Kieffer, Gen. Ins., Fasc. 152, p. 221. (1913)

Larva.—(Pl. XLIV, Fig. 1). Length 8 mm. White (alcoholic specimens), head and spiracles black.

Head consisting of a chitinized frame with enclosed membranous areas (Pl. XLIV, Fig. 6); antennae slender, 2-jointed, rather small. Thoracic segments with a transverse series of short black hairs near anterior margin on dorsum, the ventral surface of each segment with several small rounded elevations; prothoracic spiracles larger than the abdominal pairs. Spatula present but not as heavily chitinized as in most allied genera (Fig. 12). Dorsum of first seven abdominal segments each with a transverse pair of pseudopod-like processes the apices of which are bifid, each branch with a slender black bristle; a bifid process similar to processes of dorsum, but shorter, situated just ventrad of each spiracle; venter with 2 transverse series of short, rounded elevations; apical segment not elongated, spiracles (Fig. 9) larger than lateral pairs of other segments, situated on upper posterior margin and rather widely separated.

Pupa.—Unknown to me.

The foregoing description was made from specimens sent me by Dr. E. P. Felt, which were obtained in New York State, April 25, 1916. The larva does not agree with the characters cited for the larva of *Retinodiplosis* by Kieffer in the paper cited under the species heading here, but without material representing the other species for comparison I can not venture an opinion as to the exact generic status of *pini-inops*. The structure of the head agrees closely with that of *Cecidomyia resinicoloides*.

Monardia sp.?

Larva.—Length, 3–4 mm. Body cylindrical, the segments clearly defined. Head (Pl. XLIV, Fig. 3) more fully developed than in the preceding species, the antennae much stouter. Spatula tridentate, heavily chitinized; prothoracic spiracles larger than abdominal pairs. Abdominal spiracles small, present on the basal 7 segments; apical pair small, not elevated; locomotor spinules minute, in numerous transverse series on anterior portion of all ventral abdominal segments.

Pupa (Pl. XLIV, Fig. 7).—Length, 2 mm.

Head with 2 long hairs between bases of antennae and one hair on each eye; palpi curved along posterior margin of eye. Thorax with 4 long hairs. Legs longer than wings, the hind pair reaching beyond middle of fourth abdominal segment and distinctly beyond apices of mid pair, the latter slightly longer than fore pair. Abdomen without armature; spiracles indistinguishable.

Described from specimens submitted by Dr. E. P. Felt, from New York State.

Rhabdophaga podagrae Felt?

Rhabdophaga podagrae Felt, Bull. 124 N. Y. State Mus., p. 355. (1908)

A large number of specimens that appear to belong to this species were reared here from slightly swollen willow twigs by members of the office staff some years ago. The pupal exuvia differ from those of the following species, reared from *Bidens frondosa,* in having only 2 strong thorns on head (Pl. XLIV, Fig. 8)—lacking those on middle and lower margin of face. The thoracic respiratory organs are sessile. The abdomen has no stiff spinules on the dorsum, and the apices of the fore tarsi do not extend beyond apices of wings (Pl. XLIV, Fig. 2).

Rhabdophaga sp.?

A number of specimens of a species which probably belongs to this genus were reared from *Bidens frondosa* some years ago. The pupal exuvia present the following characters.

Pupa.—Head with a pair of very strong acutely pointed thorns at base of antennae (Pl. XLIV, Fig. 5), a much smaller pair below these, on center of face, which are curved upward and fused nearly to apices, and 3 small upwardly directed spines, on a common base, on lower portion of face (Pl. XLIV, Fig. 4). Thoracic respiratory organs bristle-like, elevated and very slender; dorsum of thorax glos-

sy; legs extending much beyond apices of wings, the apices of fore and mid tarsi ending at apex of fourth segment, those of hind pair extending slightly beyond that point. Dorsum of all abdominal segments except first with stout short spines arranged in 2 transverse bands, the anterior one consisting of 3–4 series of spines, the posterior of one series; apical segment almost globose; spiracles distinct.

IMPORTANT PAPERS ON NORTH AMERICAN CECIDOMYIIDAE

Eckel, L. S.
'03. The resin-gnat *Diplosis* and three of its parasites. Ent. News, 14: 279–284.

Felt, E. P.
'06–'16. Reports of the State Entomologist of New York. (These reports include a vast amount of information upon this family, and contain by far the best articles on it that have appeared here or in Europe.)

Osten Sacken, C. R.
'62. Monographs of North American Diptera. Part I, pp. 179–198.
'69. Biological notes on Diptera. Art. I. Trans. Am. Ent. Soc., 2: 299–303.
'71. Biological notes on Diptera. Art. II and III. Trans. Am. Ent. Soc., 3: 51–54, 345–347.

Williams, F. X.
'09. The Monterey pine resin midge—*Cecidomyia resinicoloides*, n. sp. Ent. News, 20: 1–8.
'10. The anatomy of the larva of *Cecidomyia resinicoloides* Williams. Ann. Ent. Soc. Amer., 3: 45–57.

Superfamily *Bibionoidea*

I have restricted Coquillett's superfamily Bibionoidea to include only Simuliidae, Bibionidae, and Scatopsidae.

The imagines present closer affinities than do the larvae at a first glance, but characters that link the larvae are not wanting. It is very evident throughout all orders that a difference in larval habitat, and especially the difference between an aquatic and a terrestrial one, results in a very marked difference in the structure of the larva. It is possible that I have placed too much emphasis upon the structure of the imagines and overestimated the effect of different habitats upon larval structure in my grouping of the families placed here. I believe, however, that these families are closely related, in fact more closely related to each other than any one of them is to any other family in

Nematocera, and for this reason I have placed them in this superfamily.

SUPERFAMILY CHARACTERS

Larva.—Head complete; mandibles opposed; antennae well developed. Abdomen with lateral abdominal spiracles, functionless in Simuliidae and possibly so in Scatopsidae; prothoracic and anal spiracles large in Bibionidae and Scatopsidae, the anal pair separated and more or less elevated; abdomen in Simuliidae with apical protrusive blood-gills.

The larvae of Simuliidae superficially resemble those of some Chironomidae, but may be separated by the long mouth-brushes, which consist of many slender branches upon a common base, opening and closing fanwise. Somewhat similar mouth-brushes are found in some related, and also in some quite unrelated, forms, and are evidently independently developed to meet the requirements of a particular mode of life.

Pupa.—The pupae of all the families are short and stout, and those that I have examined present a wide diversity of characters. In Simuliidae we find the pupae partly enclosed in cocoons, the structure of which varies somewhat with the species, and in the pupae of all species of the family the respiratory organs consist of a number of slender filaments attached to a common base on each side of thorax anteriorly. The abdomen is armed with short spines in transverse series, which aid in retaining a hold upon the surface of the cocoon. Scatopsidae, or at least the species known to me, differ in having the pupa free, the thoracic respiratory organs furcate, and the abdomen without spines, but with the spiracles elevated. Bibionidae have neither elevated thoracic respiratory organs nor abdominal spines, and show a more primitive structure throughout. The pupae of all the families have the legs straight—a character which readily separates them from the pupae of the chironomid and culicid groups.

Imago.—Antennae 8- to 12-jointed; eyes of male sometimes contiguous above and with the facets of the upper half much larger than those of the lower; eyes of female separated; ocelli present or absent; proboscis short, in part chitinized in Simuliidae. Wings large, the veins of the anterior portion much stronger than those of the posterior; posterior cross-vein never present.

Family *BIBIONIDAE*

The larvae which I have examined differ from those of every other family I have seen in three particulars: the false segment behind

the head is fully developed and armed with spinose processes; the prothoracic spiracle is apparently on the second segment; and metathoracic spiracles are present. For an idea of the general appearance of the larva, see Figure 10, Plate XLIV.

The larva of *Plecia* as figured by de Meijere agrees in all essential details with that of *Bibio**.

The characters of the larva indicate that is is structurally very primitive, and in comparison with the adult it is apparent that in this family larval specialization has not gone forward as fast as has the specialization of the imago, the advancement of the latter being evidenced by the reduction of the number of antennal joints and wing veins. In the Tipulidae the reverse is true, larval specialization being farther along than that of the imago, and distinctly in advance of that of the larva of Bibionidae.

The presence of the pseudosegment and the additional pair of spiracles on the last thoracic segment readily separate Bibionidae from Scatopsidae.

FAMILY CHARACTERS

Larva (Pl. XLIV, Fig. 10).—Head complete; mandibles opposed; antennae pedunculate. Body apparently 13-segmented, and with pointed fleshy processes; pseudopods absent; a pair of spiracles on prothorax(second apparent segment), another on metathorax, and one pair on each of the following seven segments; anal spiracles very large, sessile, situated near anterior margin of segment.

Pupa (Pl. XLIV, Fig. 11).—Antennae rather short, curved, lying across upper half of eyes; palpi directed laterad. Thoracic respiratory organs very slightly elevated; legs short, tarsi of fore pair lying over those of mid pair and not extending to their apices, the apices of mid pair extending to apices of wings, apices of hind pair extending slightly beyond apices of wings; wings extending nearly to apex of second segment of abdomen, overlying and hiding all but apices of hind tarsi. Abdomen without spines or bristles.

HABITS OF LARVAE

The larvae, as far as known, are scavengers, feeding in the earth upon decaying roots or other portions of dead plants, and are very often found in large numbers closely congregated under fallen logs and, occasionally, under horse dung and cow dung. The species are very

*Tijd. v. Ent., Vol. 53, pp. 59–63; Pl. IV, Fig. 1. (1910)

difficult to rear, and very few reared specimens are before me although several species are not uncommon in this vicinity.

I have reared one hymenopterous parasite from a breeding-cage containing larvae of this family, but doubt its connection with *Bibio* as its host.

HABITS OF IMAGINES

The imagines of *Bibio femoratus* fly in April in this latitude and are sometimes very common. The name "March-fly", applied to adults of the family by some writers, does not justify the natural interpretation of the term, as they do not appear in this country until later in the year than March. The term is probably due to a misinterpretation of the significance of the specific name of a European species of *Bibio, B. marci,* supposed to owe its name to its occurrence on the wing about St. Mark's Day (April 25). Popular names are very frequently misleading, and no encouragement should be given to the currency of any which may be derived from the characteristics of a single species, which can never properly serve as a criterion by which to judge of the remainder of the family.

The species that occur early in the season are instrumental in pollinating blossoms of various fruit-trees, upon which they occur very commonly. They fly readily even on dull days, and on this account are more generally serviceable as pollinators than bees, which are seldom active except during sunshine.

Important Papers on Biology of North American Species

Lintner, J. A.

'85. Second Annual Report of the State Entomologist of New York, pp. 110–115. (Gives description of imago of *Bibio albipennis* and notes on life history.)

Needham, J. G.

'02. A remarkable occurrence of the fly *Bibio fraternus* Loew. Am. Nat., 36 : 181. (Gives figures of larva and pupa.)

Family *SCATOPSIDAE*

Until recently the species of this family have been included in the family Bibionidae, but all stages of the species herein dealt with present good characters for their separation from that family.

FAMILY CHARACTERS

Larva.—Head complete; mandibles opposed, antennae elongate. Larva peripneustic, having prothoracic and elevated lateral abdominal and apical abdominal spiracles, the latter situated upon 2 widely separated stalk-like protuberances. Body with slender hairs.

Pupa.—Head without thorns; antennae curved over upper portion of eyes. Thoracic respiratory organs pedunculate, in the species before me furcate. Wings short; apices of hind legs barely extending beyond apices of wings. Abdomen unarmed; spiracles elevated, stalklike.

Imago.—Separable from Bibionidae by the wing venation. (See key to imagines of Nematocera.)

HABITS OF LARVAE

The larvae of this family are scavengers, feeding in manure and on decaying vegetation. I have also found them under loose bark of fallen trees.

HABITS OF IMAGINES

The flies are found on flowers, manure, decaying fruit, and very frequently on windows.

RHEGMOCLEMA ATRATA Say

Scatopse atrata Say, Appendix to Keating's Narrative of an Expedition to the Source of St. Peter's River, p. 367. (1824)

Scatopse fuscipes Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 6, p. 314. (1830)

Scatopse recurva Loew, Linnaea Ent., Vol. 1, p. 330. (1846)

Rhegmoclema atrata (Say) Melander, Bull. 130, Wash. Agr. Exper. Station, p. 12. (1916)

Larva (Pl. XLV, Fig. 1).—Length, 3–4 mm. Yellowish gray; head brownish yellow; surface hairs on body pale brown; spiracular protuberances blackish; apical respiratory processes brownish yellow; apical processes caudad of the latter black.

Antennae longer than in *Bibio* (Pl. XLV, Fig. 8). Pseudosegment indistinguishable; prothoracic spiracles more distinctly elevated than the abdominal pairs; metathorax without spiracles. Entire body covered with rather short slender hairs. Apical segment with 4 processes on dorsum—a pair near base which are stouter than the preapical pair and bear the spiracles, and a much more slender pair near apex which are crowned with several short hairs. Abdominal spiracles slightly elevated.

Pupa (Pl. XLV, Fig. 2).—Length, 2.5–3.5 mm. Darker than the larva.

Head declivitous anteriorly (Pl. XLV, Fig. 3); antennae much longer than in *Bibio*, extending to bases of wings (Fig. 4); palpi directed slightly cephalad. Thoracic respiratory organs (Fig. 5) furcate, as long as width of thorax; fore tarsi overlying mid femora, ending much proximad of apices of mid pair, the latter ending at apices of wings and very slightly proximad of apices of hind pair (Fig. 4). Basal segment of abdomen shorter than second and without an elevated spiracle (Fig. 3), the next 6 segments with stalk-like spiracles; entire body without hairs or bristles.

The foregoing descriptions were made from examples obtained from cattle cars on the railroad siding at White Heath, Ill., June 24, 1916. These cars had not been cleaned, and there was about four inches of straw and manure in the bottom of each, in which were thousands of larvae of *Rhegmoclema, Sciara,* Muscidae, *Borborus, Leptocera,* and Coleoptera. Such cars serve to disseminate manure-frequenting species, and should not be allowed to stand for a week or two uncleaned on sidings, as in this case.

I have also reared *R. atrata* from rotten plums.

Paper on North American Scatopsidae

Melander, A. L.
'16. The dipterous family Scatopsidae. Bull. 30, Wash. Agr. Exper. Station, Div. Ent. and Zool. (1916)

Family *SIMULIIDAE*

This family is of very small extent, consisting of but three genera. The species are not very numerous, but some of them occur in vast numbers in certain parts of this country and in Europe. The common names black-flies, sand-flies, and buffalo-gnats have been applied to them in this country.

In 1914 I published a revision of the North American species which will be found useful to any student of the group who intends making identifications of our native species. This and other papers on the Simuliidae are listed at the end of this summary of the family.

FAMILY CHARACTERS

Larva (Pl. XLVI, Fig. 1).—Head complete; maxillae very large, armed with very large mouth-brushes; labium dentate; thorax with

a pair of closely fused pseudopods; thoracic segments slightly swollen; apical 3–4 segments of abdomen much swollen, giving the larva a slightly club-shaped appearance; apical segment with a sucker-like disc which is armed with a number of stout, short, hook-like bristles arranged in concentric series.

Pupa (Pl. XLV, Fig. 9; Pl. XLVI, Figs. 2, 3).—Head without projecting spines; palpi directed caudad; thoracic respiratory organs each consisting of 4 to 60 tube-like filaments; legs extending but little beyond apices of wings; abdomen armed with short spines on apices of segments. The pupae are enclosed in a slipper-shaped or pocket-like cocoon (Pl. XLVI, Fig. 4) or occasionally in a tangled mass of loose threads.

Imago.—Antennae 11-jointed, the joints of the flagellum short and rather closely attached. Eyes of male confluent, with the facets of the upper half much larger than those of the lower half (Pl. XLVI, Fig. 5); eyes of female rather widely separated, the facets of nearly uniform size throughout. Wings without cross-veins in the disc; radius with 2 or 3 branches. Abdomen with 7–8 segments, and a flap-like scale at base the apex of which is fringed with long soft hairs. Legs stout; metatarsus very long and stout; claws trifid in male, bifid or simple in female.

HABITS OF LARVAE

The known larvae of the species of this family are aquatic, invariably living in water that is in motion, never occurring in ponds or stagnant water. Removal to still water in vials or other vessels results in the death of the specimens in a few hours. The food of the larvae consists of diatoms, algae, and other minute organisms. When disturbed in the streams in which they occur the larvae usually release their hold upon the surface of the rock, or other object in the bed of the stream, and float off to some distance, maintaining slight attachment, however, by means of a silken thread which emanates from the mouth. When the danger has passed they regain their former hold in the bed of the stream by means of this thread. Their method of locomotion reminds one forcibly of that of the geometrid moths, consisting of a series of looping movements, interrupted by frequent pauses during which the head and the anterior portion of the body are moved restlessly from side to side as if the insect were looking for something. Most species hibernate in the larval stage, appearing as imagines in spring and early summer. A few species have evidently more than one brood in the year.

The larvae are very commonly attacked by internal bacteria and other parasitic organisms, but are not, as far as I know, subject to attack by insect parasites.

HABITS OF IMAGINES

The species occur in the neighborhood of rivers and streams, and some are very persistent biters, attacking cattle, domestic fowls and animals, and even man. The bite is very painful, and cases are on record of the death of horses and mules as the result of their attacks. There are also a few records of the death of persons from the same cause. Within the past twenty years or so the species have evidently grown comparatively scarce in the Mississippi Valley, being now very seldom reported as injurious there. The building of levees along the rivers in the middle West, with the coincident reduction in flooding and the subsequent falling of the water which supplied the necessary breeding conditions for these insects, has contributed largely to the decrease in their numbers.

Principal Papers on North American Simuliidae

Barnard, W. S.
'80. Notes on the development of a black fly (*Simulium*) common in the rapids around Ithaca, N. Y. Am. Ent., 3:191–193.

Forbes, S. A.
'12. Black-flies and Buffalo-gnats (*Simulium*) as possible carriers of pellagra in Illinois. 27th Rep. State Ent. Ill., pp. 21–55.

Garman, H.
'12. A preliminary study of Kentucky localities in which pellagra is prevalent. Bull. 159, Ky. Agr. Exper. Station.

Hagen, H. A.
'80. A new species of *Simulium* with a remarkable nymphal case. Proc. Bost. Soc. Nat. Hist., 20:305–307.
'83. *Simulium* feeding on chrysalides. Ent. Monthly Mag., 19: 254–255.

Jobbins-Pomeroy, A. W.
'16. Notes on five North American buffalo gnats of the genus *Simulium*. Bull. No. 329, U. S. Dept. Agr.

Johannsen, O. A.
'03. Aquatic nematocerous Diptera. Bull. 68, Pt. 6, N. Y. State Mus., pp. 336–388.

Lugger, O.
'96. Buffalo gnats, black flies. Sec. Ann. Rep. Ent. State Exper. Station, Univ. Minn., pp. 172–182.

Malloch, J. R.
'14. American black flies or buffalo gnats. U. S. Dept. Agr., Bur. Ent., Bull. No. 26 Tech. Ser.

Needham, J. G., and Betten, C.
'01. Aquatic insects of the Adirondacks. Bull. N. Y. State Mus., No. 47 : 393, 407–408, 574.

Osborn, H.
'96. Insects affecting domestic animals. U. S. Dept. Agr., Div. Ent., Bull. 5, new ser., pp. 31–58.

Osten Sacken, C. R.
'70. On the transformation of *Simulium*. Am. Ent. and Bot., 2: 229–331.

Riley, C. V.
'85. The southern buffalo gnat (*Simulium* sp.). Rep. Ent. U. S. Dept. Agr. for 1884 : 340–345.
'87. Buffalo gnats. Rep. Ent. U. S. Dept. Agr. for 1886 : 492–517.

Strickland, E. H.
'10. Some parasites of *Simulium* larvae and their effects on the development of the host. Biol. Bull., 21 : 302–334.
'13. Further observations on the parasites of *Simulium* larvae. Jour. Morph., 24 : 43.

Taylor, T. H.
'02. On the tracheal system of *Simulium*. Trans. Ent. Soc. London, 1902 : 701–716.

Webster, F. M.
'87. Report on buffalo gnats. U. S. Dept. Agr., Div. Ent., Bull. No. 14 : 29–39.
'89. *Simulium* or buffalo gnats. Rep. Bur. Anim. Ind., U. S. Dept. Agr., for 1887 : 456–465.
'92. Buffalo gnats (Simuliidae) in Indiana and Illinois. Proc. Ind. Acad. Sci., 1892 : 155–159.

Addenda to Nematocera

Addendum 1

When at work upon the portion of my paper dealing with Limnobiidae, I unfortunately overlooked some larvae whose family identity I had had doubts about, not returning to them as intended,

and in order to make this study as comprehensive as possible I give here a brief description of the species.

Subfamily TRICHOCERINAE

TRICHOCERA sp.?

Larva.—Length, 10 mm. Pale testaceous.

Head complete, similar to that of the Alaskan species described under the above subfamily name on a previous page of this paper. Prothoracic spiracle small, surrounded by a pale ring; anterior third of prothorax paler than posterior two thirds; each thoracic segment with a transverse linear depression at middle on dorsum, the venter without depression; first abdominal segment with a median transverse linear depression on dorsum and venter, the other segments, except the apical one, with 2 such depressions which divide the segments into 2 short anterior portions and a longer posterior one; apical segment different from that of the Alaskan species in having the ventral blood-gills distinct, in the form of an irregular protuberance (Pl. XLV, Fig. 6), and the 4 processes round the spiracular disc shorter and of almost uniform length (Fig. 7).

Described from specimens obtained by me at White Heath, Ill., March 12, 1916, where the larvae were common under leaves and debris that had collected in depressions and holes in tree-stumps several feet high in a wood along the bank of the Sangamon River. The eggs may have been deposited by late-flying adults after snow covered the ground, when the tree-stumps only were free from it, and this may account for the occurrence of the larvae in this elevated situation. I failed in my attempt to rear the species, and having provisionally placed it in Bibionidae I overlooked it till it was too late to include it in its proper place in this paper.

Addendum 2

The species described below is evidently a limnobiid, but I do not care to venture a suggestion as to its affinities. Though the head bears a resemblance to that of Pediciinae, the apical segment is quite different from that of the species of that family known to me.

GENUS INCERTUS

Larva.—Length, 10 mm.; diameter, 1 mm. Yellowish testaceous; head dark brown on the more heavily chitinized parts, remainder pale brown; anal respiratory disc dark brown.

Head retractile, narrow; dorsal slits very narrow, ventral one broad and extending so far forward that the labium is divided centrally; antennae very short and stout; labrum obtuse at apex; maxillae stout, palpi very robust, nearly as thick as the maxillae and slightly shorter; mandibles stout, slightly curved, their apices obtusely rounded, teeth short, rounded, 3 in number, all on a median protuberance; labium divided in center, the sides without distinct teeth. Body cylindrical, covered with dense decumbent pile, segments longer than broad, with the usual transverse incised lines present in Limnobiidae; apical segment shorter than preapical, its posterior surface obliquely truncate, heavily chitinized, the spiracles small and widely separated, situated near upper extremity of the round plate; ventral blood-gills absent.

Described from a specimen in the collection of this Laboratory which was taken in a cabbage field at Rose Hill, Cook Co., Ill., September 26, 1883.

The round heavily chitinized apical plate is very similar to that of *Coenomyia.*

Division BRACHYCERA

There is a diversity of opinion among systematists regarding the arrangement of the families of this division, and while the general scheme in the present paper is essentially the same as that proposed by Brauer it differs in some respects from that of any previously published classification. The two tribes, Platygenya and Orthogenya, are those used by Brauer, but I have discarded his group names Homeodactyla and Heterodactyla, retaining the superfamily divisions which he indicated, but using names derived from one of the included families in order to conform to the rules governing nomenclature. Both of Brauer's discarded groups—which have a status between his tribe and superfamily—are heterogeneous, and while the present arrangement may not be ideal, it appears to me a better and less cumbersome one than Brauer's.

The classification adopted by Verrall differs in many respects from that of Brauer, and is based entirely on imaginal characters. I can not accept Verrall's linking together of Scenopinidae and Mydaidae in one superfamily in view of the close resemblance between the larvae of the former with those of Therevidae, and consider that they really belong to the same superfamily as Therevidae despite some resemblances the imagines bear to those of Mydaidae.

It is unnecessary to go into details regarding the various classifications proposed. A resumé of them may be found in Williston's Man-

ual of North American Diptera (1909) and in Verrall's British Flies, volume 5 (1909).

Tabular Arrangement of Families

*Tribes**	*Superfamilies*	*Families*†
Platygenya	Stratiomyioidea	Stratiomyiidae Xylophagidae Coenomyiidae Acanthomeridae
	Tabanoidea	Tabanidae Leptidae
	Cyrtoidea	Cyrtidae Nemestrinidae
	Asiloidea	Mydaidae Apioceridae Asilidae Bombyliidae
	Therevoidea	Therevidae Scenopinidae
Orthogenya	Empididoidea	Empididae Dolichopodidae

Keys to Families

LARVAE

1. Posterior spiracles approximated, situated within a terminal or subterminal cleft or chamber, usually concealed; body entirely shagreened or wholly or in part longitudinally striated...........2

— Posterior spiracles rather widely separated, visible, situated on apical segment, which may be truncated, chitinized, or armed with

*Tribe in this paper does not have the application given to it in contemporary papers, but has that which Brauer gave it. He used it to designate his subdivisions of the larger divisions of Nematocera and Brachycera.

†The sequence of the families in the keys is not in accordance with the above list, the keys being framed to facilitate identification and not to indicate affinities.

apical processes; or upon penultimate or antepenultimate segment; body not shagreened or visibly striated.................3

2. Head not retractile; body flattened, surface finely shagreened, sometimes with lateral abdominal spiracles, without vestigial pseudopods; spiracular fissure transverse, sometimes rather small; pupae enclosed in larval skin..........STRATIOMYIIDAE (p. 315).

— Head retractile; body cylindrical, surface not shagreened, usually longitudinally striated, abdomen with a girdle of pseudopods on each segment; spiracular fissure vertical; pupa free..TABANIDAE (p. 355).

3. Posterior spiracles situated upon apical segment................4

— Posterior spiracles situated upon penultimate or antepenultimate segment...10

4. Projecting portion of head and flattened apical plate of terminal abdominal segment heavily chitinized: the former cone-shaped, entirely closed except at extreme apex, not retractile; the latter obliquely truncate and with projecting processes..............5

— Projecting portion of head more or less retractile, not cone-shaped, the movable portions not enclosed; apical abdominal segment without a heavily chitinized flattened terminal plate..........6

5. Head about twice as long as its greatest width; thoracic segments not chitinized above, each with 2 internal separated chitinized plates; body without long hairs; apical plate very large, spiracles vertically elongated, apical paired protuberances small, widely separated, each with a short hair on inner side..COENOMYIIDAE (p. 351).

— Head at least 3 times as long as its greatest width; at least the first and second thoracic segments chitinized above, no internal chitinized plates present; body with a number of long hairs, 4 of which, in a vertical series on each abdominal segment, are very noticeable; apical plate rather small, spiracles rounded, apical paired protuberances large, fused basally, each with a number of rather long hairs..........................XYLOPHAGIDAE (p. 346).

6. Posterior spiracles widely separated, located in an apical transverse cleft; head very small, retractile........NEMESTRINIDAE (p. 368).

— Spiracles not located in an apical transverse cleft...............7

7. Apical abdominal segment ending in 2 long processes which are fringed with long soft hairs; abdomen with paired pseudopods and fleshy dorsal and lateral appendages. .LEPTIDAE, pt. (p. 362).

— Apical abdominal segment not as above, paired abdominal pseudopods usually, other appendages always, absent................8

8. Apical abdominal segment ending in 4 short pointed processes or 2 fleshy lips; internal portion of head with a large, arched, chitinized upper plate, the longitudinal rods and other cephalic parts on a horizontal plane...................LEPTIDAE, pt. (p. 362).

— Apical abdominal segment not as above, or the internal portion of head is without arched upper plate, and the longitudinal cephalic rods and other cephalic parts meet at right angles.............9

9. Apical abdominal segment without projecting processes, the spiracles very small; species internal parasites of spiders........... ....CYRTIDAE (p. 368).

— Apical abdominal segment frequently with projecting processes, the spiracles large; species living in water, mud, earth, or decaying vegetable matter.................. { EMPIDIDAE......(p. 400). DOLICHOPODIDAE (p. 403).

10. Posterior spiracles situated upon antepenultimate segment: abdominal segments 1–6 subdivided, the body apparently consisting of 20 segments exclusive of the head.......................11

— Posterior spiracles situated upon penultimate segment; abdominal segments simple, the body apparently consisting of 11 or 12 segments exclusive of the head..............................12

11. Posterior dorsal internal extension of head spatulate at apex; ventral posterior projections in the form of 2 short chitinized rods.. ....THEREVIDAE (p. 396).

— Posterior dorsal internal extension of head not spatulate at apex; ventral posterior projections absent......SCENOPINIDAE (p. 398).

12. Penultimate abdominal segment longer than ultimate, with a deep transverse depression near its apex giving it the appearance of 2 distinct segments; ultimate segment terminating in a sharp ridge with a median sharp point, on either side of which dorsally and ventrally are situated 4 very closely approximated hairs similar to those in Asilidae......................MYDAIDAE (p. 370).

— Penultimate abdominal segment shorter than ultimate, or if longer, then without a deep transverse depression; apical segment not as above, the hairs not closely approximated...................13

13. Thoracic segments each with 2 long hairs, one on each side on ventro-lateral margin; apical segment with 6 or 8 long hairs; head well developed, forwardly protruded, and more or less cone-shaped when viewed from above, appearing flattened when viewed from the side; penultimate segment usually shorter than ultimate or not much longer; body straight in life.....ASILIDAE (p. 373).

— Thoracic segments without hairs, or if these are present they are very weak; apical segment without distinguishable hairs; head not much protruded, directed downward, not cone-shaped, with a dorsal protuberance when viewed from the side; penultimate segment distinctly longer than ultimate; body usually curved in a half circle in life.....................BOMBYLIIDAE (p. 389).

PUPAE

1. Pupa enclosed within the last larval skin..STRATIOMYIIDAE (p. 315).

— Pupa free...2

2. Prothorax with a large aperture mesad of and connected with the spiracle..............................TABANIDAE (p. 355).
— Prothorax without an aperture mesad of the spiracle............3
3. Head without strong forwardly directed thorns, at most with one thorn on base of antenna which is directed laterad; abdominal armature weak, becoming gradually stronger towards apex of abdomen; wings short, extending to or very slightly beyond apex of basal abdominal segment; apices of hind tarsi at most extending slightly beyond apices of wings; abdomen with 7 pairs of spiracles 4
— Head usually with strong thorns, or if these are absent the abdominal armature is stronger on basal or second segment than it is on apical or there are less than 7 pairs of abdominal spiracles present; apices of hind tarsi usually extending distinctly beyond apices of wings...6
4. Antennal sheaths much thickened at bases, apical portion slender, styliform, the whole directed almost straight downward........ ....LEPTIDAE (p. 362).
— Antennal sheaths thickened throughout their length, the apical portion generally more or less distinctly annulated, the whole directed either straight laterad or in a slightly downward direction..5
5. Antennal sheaths very stout, not over twice as long as their basal breadth; face with a small sharp protuberance on each side a little mesad of the vertical line of apices of antennae and slightly above middle of face, and at the base of each are 2 short hairs on their inner side; 2 very strong postspiracular abdominal bristles on each segment...............COENOMYIIDAE (p. 351).
— Antennal sheaths distinctly annulated, slender, about 4 times as long as their basal breadth; face without protuberance; postspiracular abdominal bristles slender, 8–10 on each segment.............. ..................................XYLOPHAGIDAE (p. 346).
6. Head without strong thorns; abdomen with 3–4 distinct pairs of spiracles and without spinose armature......CYRTIDAE (p. 368).
— Head usually with strong thorns, at least with elevated ridge-like antennal sheath and several small carinated elevations; abdomen with 7 pairs of spiracles and spinose armature................7
7. Head with 2 thorns...8
— Head with more than 2 thorns or with several short tubercles.....9
8. Abdomen with a single transverse series of spines on each dorsal segment; wing with a long thorn at base....THEREVIDAE (p. 396).
— Abdomen with 2 transverse series of spines on each dorsal segment; wing without thorn at base.............SCENOPINIDAE (p. 398).
9. Upper pair of cephalic thorns directed laterad and slightly upward; apices of wings extending to or very slightly beyond apex of first abdominal segment; apices of middle tarsi not extending to apices of wings..............................MYDAIDAE (p. 370).

— Upper pair of cephalic thorns directed forward, at most slightly divergent apically, generally slightly curved downward or head without strong upper thorn.............................10

10. Head with strong thorns, or if these are absent the abdomen has the dorsal transverse armature consisting of very strong thorns and intervening long slender hairs; apices of antennae obtuse..11

— Head very rarely with strong thorns, 2 carinate elevations present on upper anterior margin; antennae with apices attenuated; body without thorns, sometimes with bristles....................12

11. Lower median portion of face with a closely approximated pair of stout thorns which are occasionally fused almost to apices; abdomen with the transverse armature of the dorsal segments consisting of short flattened thorns and long slender hairs, the thorns usually appearing as if attached to rather than forming a part of the abdomen and sometimes turned up at bases and apices...... ....BOMBYLIIDAE (p. 389).

— Lower median portion of face without thorns; abdomen with the transverse armature consisting of alternating long and short thorns except in *Leptogaster*................ASILIDAE (p. 373).

12. Cephalic armature consisting of 2 carinated elevations on upper anterior margin, on each of which is a very long hair; antennal sheaths raised above level of face, tapering apically, directed downward and slightly outward; proboscis much elongated..... ....EMPIDIDAE (p. 400).

— Similar to foregoing, but with the proboscis short................ ................................DOLICHOPODIDAE (p. 403).

IMAGINES

1. Empodium pulvilliform, nearly or quite as large as the pulvilli, so that 3 rounded pads or scales appear under the tarsal claws....2

— Empodium either absent or in the form of a slender thread, with or without surface hairs, so that there are only 2 distinct pads or scales under the tarsal claws.................................8

2. Third antennal joint distinctly annulated or the antenna consisting of more than 3 distinct joints..........................3

— Antenna consisting of 3 joints, the third not annulated..........6

3. Costal vein discontinued at or close to the apex of wing........... ....{ STRATIOMYIIDAE* (p. 315). ACANTHOMERIDAE (p. 354).

— Costal vein continued round apex of wing, sometimes encircling the whole posterior margin....................................4

4. Squamae very large......................TABANIDAE (p. 355).

— Squamae small, sometimes vestigial............................5

*The family Acanthomeridae is doubtfully distinct from Stratiomyiidae. I have no species of the former, all occurring in South America.

5. Robust species, with spinose scutellum; marginal vein encircling wing..............................COENOMYIIDAE (p. 351).
— Slender species, with unspined scutellum; marginal vein ceasing before reaching anal angle of wing........XYLOPHAGIDAE (p. 346).
6. Squamae very large, inflated; robust flies, with very small heads...CYRTIDAE (p. 368).
— Squamae very small...7
7. Costa continued round posterior margin of wing...LEPTIDAE (p. 362).
— Costa discontinued at apex of wing.......NEMESTRINIDAE (p. 368).
8. Anal cell much longer than second basal, closed at or close to wing-margin, or open; third vein usually furcate..................9
— Anal cell absent or, if present, shorter than second basal, or but little longer, and closed some distance from wing-margin; if the apex of this cell is long and pointed the third vein is not forked 14
9. Vertex depressed, seen from in front the upper inner angles of eyes are considerably above the level of the frons; eyes always separated..10
— Vertex not depressed, at least on a level with upper inner angles of eyes; eyes of male often contiguous......................11
10. Fourth vein curved forward apically, ending at or before tip of wing.....................................MYDAIDAE (p. 370).
— Fourth vein not curved forward...............ASILIDAE (p. 373).
11. Posterior cross-vein present, i. e., second basal cell with an obtuse apex formed by a cross vein; 5 posterior cells present........12
— Posterior cross-vein absent, i.e., second basal cell with an acute apex; rarely 5 posterior cells present, if present the fifth cell is due to the bisection of the third by a cross vein..............13
12. Fourth vein curved forward and ending before the apex of wing.....................................APIOCERIDAE (p. 373).
— Fourth vein not appreciably curved forward, ending behind apex of wing.................................THEREVIDAE (p. 396).
13. Fourth vein curved forward, ending at or before apex of wing; proboscis retracted, fleshy; antennae without apical style...SCENOPINIDAE (p. 398).
— Fourth vein ending behind apex of wing; proboscis slender, usually much exserted; antenna usually with a style..BOMBYLIIDAE (p. 389).
14. Discal cell usually separated from the second basal, always at least one distinct basal cell; squamae small; abdomen of male usually with 7 segments exclusive of the hypopygium; black, brownish, or yellowish species, usually with chitinized proboscis..EMPIDIDAE (p. 400).
— Discal cell not separated from second basal, the basal cells small and indistinct; squamae moderately large, usually with con-

spicuous fringe; abdomen of male usually with 5 or 6 segments in addition to the hypopygium; metallic greenish or bluish species, usually with fleshy proboscis. . . DOLICHOPODIDAE (p. 403).

Tribe PLATYGENYA

The larvae of members of this tribe are distinguished from those of Orthogenya by the structure of the head, the plates forming it being flat and straight, when not enclosed within a conical chitinized capsule, and lying on a horizontal plane when at rest. Occasionally the exposed portion of the head is heavily chitinized on the anterior half, forming a cone from whose small apical opening the mandibulate processes protrude.

I am unable to give characters for the differentiation of the pupae of this tribe from those of Orthogenya, the species of the latter known to me being so few that a generalization based on them would probably prove misleading.

This tribe contains all of the Brachycera except Dolichopodidae and Empididae. Characters for the separation of these families will be found in the preceding key to different stages.

Superfamily *Stratiomyioidea*

SUPERFAMILY CHARACTERS

The family Acanthomeridae is confined to tropical America and is unknown to me, but the other three families are represented in all stages in my material.

Larva.—Head with the anterior half cone-shaped, permanently exserted, in Xylophagidae and Cecidomyiidae heavily chitinized, the mandibulate processes protruded through a small opening in the apex. The larvae of Stratiomyiidae have the head less heavily chitinized than do those of the other two families known to me in that stage, but the anterior half is non-retractile—a character which separates these larvae from those of other superfamilies. Many of the genera have distinguishable spiracles on metathorax and abdomen which are probably not functional. For other distinguishing characters see key to larvae of Brachycera and descriptions under family headings.

Pupa.—The pupae of Stratiomyiidae are enclosed within the last larval skin—a fact which separates them from other Brachycera. The pupae of Xylophagidae and Coenomyiidae are free, and differ from those of other Brachycera known to me in having the antennae with well-defined annuli.

Imago.—See key to imagines of Brachycera.

Family *STRATIOMYIIDAE*

The larvae of this family are readily separated from those of any allied family by their characteristic general appearance (Pl. XLVII, Figs. 1, 2, 3), and the finely shagreened surface of the body. All the genera so far described have larvae that differ appreciably in the following details: head structure, chaetotaxy, indentation of lateral margins of abdominal segments, length and structure of the apical segment, and structure and armature of the anal respiratory chamber. In the aquatic forms the apical respiratory chamber, which contains the openings of the spiracles, is furnished along its margins with long plumose hairs. When the larva is close to the surface of the water the anal extremity is curved upward till the tips of the respiratory or spiracular chamber are free of the water, the radiating hairs then expanding upon the surface film and preventing the water from flooding the chamber and interfering with respiration. When the larva descends below the surface the hairs are drawn inward, enclosing a large air-bubble which is carried in this manner until nearly exhausted, when the larva again ascends to the surface. The terrestrial forms lack the plumose hairs bordering the anal respiratory chamber and the latter is in some genera located upon the disc of the segment some distance before the apex instead of at the extreme apex as in the aquatic forms.

No other species in Orthorrhapha known to me, except a few in Cecidomyiidae, transform to the pupal stage within the larval skin, and because of this peculiarity it will only be necessary to give a key to the larvae in the family. I have mainly used material in the Laboratory collection in drawing up the keys presented, but in a few cases I have also made use of published descriptions or borrowed material.

CHARACTERS OF THE FAMILY

Larvae and Puparia.—Twelve-segmented exclusive of the head, the latter attached at middle to first thoracic segment, and usually with a distinct ocular prominence on each side at varying distances from front margin and numerous long hairs on dorsum and venter; antennae distinct; pseudopods absent, penultimate and antepenultimate segments sometimes armed with locomotor hooks on caudal margin of ventral surface; anterior spiracles near posterior margin of side of first segment; lateral metathoracic and abdominal spiracles present or absent; posterior spiracles separated, located in a transverse slit-like cavity which may be apical or preapical and fringed with long plumose hairs or unfringed; entire surface of body finely shagreened.

HABITS OF LARVAE

The aquatic larvae feed upon algae, decaying vegetable matter, and small Crustacea. The terrestrial species occur in a variety of situations, some of them being found in nests of Hymenoptera, or in those of rodents—where they act as scavengers; others occuring under loose bark of living or recently felled trees, feeding upon the sap, or on dipterous larvae; while still others feed upon decaying vegetation or on manure. One genus (*Hermetia*) has been recorded as feeding upon the dead body of a man.

HABITS OF IMAGINES

The species are most active on sunshiny days, some of them being much given to settling upon leaves of trees which are in full sunlight. Most species frequent flowers, especially those of Umbelliferae, feeding upon the nectar, and are particularly numerous on marshy ground or along the margins of streams, ponds, or other bodies of fresh water. Few species occur on the seashore and I know of none that that are found in the larval stage in salt water.

The eggs are usually laid in masses on the leaves of aquatic plants, as shown in Figure 4, Plate XLVII.

Key to Subfamilies

LARVAE AND PUPARIA

1. Apical abdominal segment very much longer than broad and very distinctly tapered, but if the length is not over 3 times that of the basal width the antepenultimate and penultimate ventral segments have each 2 or 4 stout curved thorns on their posterior margins; posterior spiracular chamber at apex of last segment, the margin armed with numerous soft, plumose or pubescent hairs; aquatic species................Stratiomyiinae (p. 317).

— Apical abdominal segment not over twice as long as its basal width; if the species is aquatic and has the posterior spiracular chamber armed with marginal hairs the ventral thorns are absent......2

2. Aquatic species; bristles on dorsum paired, very short, sometimes thickened apically; posterior spiracular chamber margined with long, soft, plumose or pubescent hairs........................ ....Clitellariinae, pt. (p. 322).

— Terrestrial species; bristles on dorsum single, long and tapered, or in groups; posterior spiracular chamber on dorsum of apical segment, transverse, not margined with soft hairs................3

3. Each segment with a deep notch in each lateral margin slightly before middle, dividing the segment into 2 unequal lateral lobes (Pl. XLIX, Fig. 11)...............*Genus incertus* 1 (p. 344).

— Segments without lateral notch.................................4
4. Bristles on dorsum very short, arranged in groups of 3–4; lateral bristles arranged similarly, two such groups on each side of each segment.................................BERIDINAE (p. 331).
— Bristles on dorsum and lateral margins long, not in groups.......5
5. Head much elongated, the portion anterior to eyes distinctly longer than its greatest width; antennae of moderate length, apical portion slender; the 6 conspicuous hairs on dorsal surface of thoracic and abdominal segments not in an almost straight transverse series, the median pair close to anterior margin and very much longer and stronger than the 2 lateral pairs, which are close to posterior margin; thorax and abdomen without long decumbent hairs.............................*Genus incertus* 2 (p. 345).
— Head not much elongated, the portion anterior to eyes about as long as its greatest width; or if the head is elongated the hairs on abdomen are in straight or almost straight transverse series......6
6. Very large robust species, over 18 mm. in length; antennae of moderate length, apical portion stout; eyes moderately prominent; head distinctly narrowed immediately behind eyes, almost parallel-sided; thoracic and abdominal segments densely covered with decumbent lanceolate hairs.................CLITELLARIINAE, pt.
— Smaller species, 10–12 mm. in length at most; antennae very small; eyes very prominent.......................................7
7. Thoracic segments 1 and 2 each with a smooth plate on dorsum; apical segment with a transverse series of short teeth near base on ventral surface which are directed caudad...XYLOMYIINAE (p. 340).
— Thoracic segments without smooth plate on dorsum.............8
8. Bristles slightly clubbed with the exception of some of those on head and those on apical segment......*Genus incertus* 3 (p. 345).
— Bristles tapered to a point, not clubbed.........................9
9. Robust species; dorsum distinctly striate; head short and broad.....................................GEOSARGINAE (p. 331).
— Slender species; dorsum unicolorous, brown or testaceous; head long and slender.......................PACHYGASTERINAE (p. 334).

Subfamily STRATIOMYIINAE

SUBFAMILY CHARACTERS

Larva and Puparium.—Head elongate, armed as in Figures 1 and 2, Plate XLVIII; antennae well developed; maxillae very elaborate, the palpi well developed; mandibles weakly chitinized, the teeth slender. Body with rather weak armature, sometimes with scale-like hairs on dorsum, and in *Odontomyia* with strong thorns (2 or 4) on posterior margin of penultimate, or of both penultimate and ante-

penultimate, ventral segments; lateral abdominal spiracles indistinguishable; apical segment much elongated; the apical 3 or 4 segments tapered posteriorly in *Stratiomyia*; posterior spiracular chamber in apex of last segment, fringed with long soft hairs.

Imago.—Third antennal joint without a differentiated arista; abdomen with 5 or 6 visible segments; 4 posterior veins in wing between apex of third vein and apex of second branch of cubitus, the first cubital branch arising from the second basal cell.

HABITS OF LARVAE

The larvae are aquatic, their food consisting of algae, decaying vegetable matter, and minute organisms such as crustaceans.

HABITS OF IMAGINES

The flies are invariably flower-frequenters, occurring in large numbers on Umbelliferae, etc.

KEY TO GENERA

LARVAE AND PUPARIA

1. Apical abdominal segment very much elongated, more than 3 times as long as its greatest width; penultimate and antepenultimate ventral segments without curved thorns; antennae about three times as long as their diameter.................... *Stratiomyia.*

— Apical abdominal segment at most 3 times as long as its basal width; penultimate and antepenultimate ventral segments, or only the former, with 2 or 4 strong curved thorns on their posterior margins; antennae about 6 times as long as their diameter.......... .... *Odontomyia.*

STRATIOMYIA Geoffroy

GENERIC CHARACTERS

Larva and Puparium (Pl. XLVII, Fig. 1).—Elongate, slightly tapering anteriorly; the head elongate, antennae short. Posteriorly the body is usually much attenuated, the last segment being more than 3 times as long as its greatest width; no curved thorns on ventral segments; dorsum with or without surface hairs, but without the well-defined transverse series of 6 bristles so noticeable in Geosarginae and Pachygasterinae, and without curved thorns on posterior margin of antepenultimate and penultimate segments ventrally.

Imago.—Robust, black species, with conspicuous yellow, greenish, or whitish markings. Abdomen with 5 or 6 visible segments; third antennal joint without a differentiated arista; 4 posterior veins present on wing, 3 of which arise from discal cell; third vein forked; scutellum spinose; basal joint of antennae at least 3 times as long as second.

HABITS OF LARVAE

The larvae are aquatic, occurring in ponds and slow-flowing streams. Their food consists of decaying vegetation and minute organisms—such as algae, diatoms, and crustaceans. Species that I have kept in the laboratory fed upon decaying leaves, eating all but the veins and main ribs. The skin of the larvae is very tough and, except just after molting, covered with a sedimentary deposit which serves to conceal the species on the mud bottoms where they occur. They become conspicuous, however, when they crawl out of the water on the muddy banks, as their skins dry out rapidly and become grayish, so that they are readily seen against the darker ground. The larvae stand drying out remarkably, some of those I had recovering upon being placed in water even after they appeared to be hard and lifeless. This faculty of recovery must prove of great value to the species which occur in shallow ponds or in streams which dry up during periods of summer drought.

HABITS OF IMAGINES

The flies are usually found on flowers of various plants, and are particularly common upon wild parsnip and wild carrot.

Key to Larvae and Puparia

1. Prothorax with slender hairs on its anterior margin; apical segment about 6 times as long as its basal width . . . . *norma.*
— Prothorax with a number of short, stout processes on its anterior margin in addition to the slender hairs; apical segment about 3 times as long as its basal width . . . . *meigeni.*

Stratiomyia norma Wiedemann

Stratiomyia norma Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 62. (1828)

Larva (Pl. XLVII, Fig. 1).—Length, 30–40 mm.; greatest diameter, 5.6 mm. Dorsum with 6 indistinct pale vittae and pale spots at bases of the slender surface hairs, lateral margins pale.

Head as in Figures 1 and 2, Plate XLVIII, the antenna not over 3 times as long as its apical diameter (Fig. 6, *a*); maxillae very complex (Fig. 3) in life, moving rapidly and alternately with an upward and downward motion; mandibles weak (Fig. 6). Entire body with rather long weak hairs, a pair on lateral margins, and 6, stronger than the others, in a transverse series on disc of each segment; apical segment about 6 times as long as its basal width, the terminal hairs of moderate length.

The foregoing description was made from material obtained in the Illinois River and used by Mr. Hart in connection with his paper previously referred to. The species is very common in the Illinois and connected rivers and streams.

For a more complete description of the external appearance of the larva and details of the life history of the species the reader is referred to Mr. Hart's paper.*

Stratiomyia meigeni Wiedemann

Stratiomyia meigeni Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 61. (1828)

Larva.—Length, 25 mm.; greatest width, 5 mm. Darker than the preceding species, the pale vittae distinct only at posterior margin of each segment.

Differs from *norma* in having a number of short, stout processes on anterior margin of dorsum of first segment, and in the length of the apical segment—which is but little more than 3 times as long as its basal width and more gradually tapered than in *norma*.

Described from specimens obtained in a small stream at Muncie, Ill., in April and May, 1916.

I had many larvae but reared only 2 imagines. The species is very common throughout the state, and the imago has been previously recorded by Mr. Hart, under the name *marginalis* Loew, from Bureau, Rock Island, McLean, and Champaign counties. It occurs commonly on flowers of wild parsnip in August at White Heath, Urbana, and Muncie.

Odontomyia Meigen

Larva and Puparium (Pl. XLVII, Figs. 2, 3).—Similar in general appearance to *Stratiomyia*, but differs in the following particulars: the antennae are longer—about 6 times as long as their apical width; the apical segment is not more than 3 times as long as its basal width

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 248–252. (1895)

and but slightly tapered; and the penultimate segment—sometimes the antepenultimate also—bears 2 or 4 curved thorns on the posterior margin of the ventral surface.

HABITS OF LARVAE

The larvae are aquatic, living in streams, particularly in those with slow current and muddy bottom. Their food consists of algae, small crustaceans, and decaying vegetable matter.

HABITS OF IMAGINES

The flies are commonly found on flowers along the margins or in the immediate vicinity of streams.

Key to Larvae

1. Dorsum with 6 pale vittae, which are usually so close together as to give the appearance of a single longitudinal band that tapers posteriorly; large species, 20–30 mm. in length.......... *cincta*.
— Dorsum with 6 pale vittae which are rather widely separated and do not form a longitudinal pale band; smaller species, 12–15 mm. in length.. *vertebrata*.

Odontomyia cincta Olivier

Odontomyia cincta Olivier, Encycl. Méth., Vol. 8, p. 432. (1811)
Odontomyia extremis Day, Proc. Acad. Nat. Sci. Phila., 1882, p. 80.

The larva (Pl. XLVII, Fig. 3) of this species has been described by Mr. Hart*. I have dissected the head and find that the maxillae and mandibles differ from those of *Stratomyia norma* as shown in Figures 3 and 6 and 5 and 7, Plate XLVIII. The larvae may also be distinguished from *Stratiomyia* as indicated in the key to genera.

The species is represented in our collection by many larvae, mostly obtained in the Illinois River. Most of the imagines were taken in the vicinity of the Sangamon and Illinois rivers, but a few were obtained at Muncie, near some small streams where the larvae were found.

Odontomyia vertebrata Say

Odontomyia vertebrata Say, Appendix to Vol. 2 of Keating's Narrative of an Expedition to the Source of St. Peter's River, etc., p. 369. (1824)

*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 260–261.

This species occurs generally throughout the state, and in fact in most parts of North America. The larva (Pl. XLVII, Fig. 2) is found in rivers and small streams, and differs from that of *cincta* in its smaller size and in the markings, as stated in key. For fuller descriptions and life histories of the two species see Mr. Hart's paper previously cited.

I have found the larvae abundant in a small stream at Muncie from April to June.

Subfamily CLITELLARIINAE

This subfamily does not, in my opinion, form a natural group. I consider that *Hermetia* does not properly belong with the aquatic forms, being more closely allied to Geosarginae in larval characters, but I leave the arrangement as in Williston's "Manual" pending further information upon the life history of other genera.

SUBFAMILY CHARACTERS

Larva and Puparium.—The larvae of the aquatic forms differ from those of Stratiomyiinae in having the apical segment comparatively shorter, almost subquadrate, and the dorsum with short thick bristles arranged in a transverse series near posterior margin of each segment except the apical. The genus *Hermetia* is terrestrial, resembles the larva of *Geosargus* in many respects (though much larger than any species of that genus known to me), and has the body slightly broadened apically, the dorsum unicolorous, and the head long and tapered anteriorly.

Key to Genera

LARVAE AND PUPARIA

1. Terrestrial species; body not tapered posteriorly; apical segment rounded; opening of the posterior spiracular chamber in the form of an unfringed transverse slit at apex of dorsum of last segment ....*Hermetia.*

— Aquatic species; body tapered anteriorly and posteriorly; apical segment elongated and more or less truncated; opening of posterior spiracular chamber fringed with soft hairs..........2

2. Posterior spiracular chamber situated on dorsum of apical segment, the fringe of hairs rather short; apical segment armed with 4 long marginal hairs..............................*Nemotelus.*

— Posterior spiracular chamber at apex of apical segment, the fringe of hairs long; apical segment without the long marginal hairs... ....*Oxycera.*

Hermetia Latreille

I have before me one larva and several puparia of a species of this genus. It is probable that the generalization given below will apply to all species of the genus.

GENERIC CHARACTERS

Larva and Puparium.—Head long, tapered anteriorly; antennae distinct but short, rather slender. Body broad, of nearly uniform width except apically, where it becomes slightly broader; surface with many short hairs, and a number of long bristles in almost straight transverse series; lateral bristles long, simple; apical segment very similar to that of *Geosargus,* the marginal bristles long; respiratory chamber terminal. Abdomen with distinct lateral spiracles on segments 1–7.

Hermetia illucens Linné

Musca illucens Linné, Syst. Natur., ed. 10, Vol. 2, p. 979. (1758)

Larva and Puparium (Pl. XLVIII, Fig. 13).—Length, 16–18 mm.; greatest width, 5 mm. Dark brown, head yellowish, dorsum unstriped.

Head long and rather narrow, the surface hairs short, arranged on dorsum as in Figure 10, Plate XLVIII; antennae short and stout, apical joint about as long as basal but much thinner. Body covered with fine short hairs and with long bristles arranged as in Figure 10; spiracles on prothorax much larger than the lateral abdominals; only 2 long bristles on sides of each thoracic segment when seen from above. Abdomen becoming broader posteriorly; spiracles distinct on segments 1–7, segments 2–5 with a small round wart just posterior to each spiracle; apical segment longer than preapical, armature of venter as in Figure 11; respiratory chamber terminal.

Described from specimens sent me by L. H. Dunn—which were found in 1915 feeding upon the dead body of a man in a jungle about three miles from one of the settlements in the Panama Canal Zone—and one specimen taken by C. A. Hart at Galveston, Texas.

Under the name *H. mucens,* Riley and Howard recorded the larvae as living upon wax, etc., in beehives*; and larvae supposed to belong to this species are recorded by Morgan† as occurring in the alimentary canal of man. He also states that they have been found

*Insect Life, Vol. 1, 1899, p. 353.

†Bull. 48, sec. ser., Louisiana Agr. Exper. Station, p. 151. (1897)

in catsup and decaying vegetables and reared from potatoes. The larvae are numerous in privies in the Southern States and in Central America.

NEMOTELUS Geoffroy

I have not seen the larva of any species of this genus. Lundbeck* has described and figured the larva of the European *pantherina*, which agrees in general characters with *uliginosus*, also of Europe, previously described by Haliday†.

The characters that serve to separate the larvae of *Nemotelus* from those of *Oxycera* are given in the key to the larvae of this subfamily (Clitellarinae).

The larvae are aquatic, and although unknown to me must be common in suitable situations throughout the state, since in the imaginal stage at least one species commonly occurs from June to August on various flowers.

OXYCERA Meigen

GENERIC CHARACTERS

Larva and Puparium.—I have found only one larva that I considered as belonging to this genus, and unfortunately it was not preserved when it died. Lundbeck's description of the larva of *trilineata* is the best available, and the following data are drawn from his paper.‡

Head conical, with small eye-spots on the anterior part and small antennae anterior to them. Segments broader than long, only the apical one a little longer than broad, rounded behind. Dorsum with stout bristles which are thickened apically, arranged in pairs, 2 pairs on each side of median line, the median pairs close together, and in addition to these bristles, which are near the posterior margin, several appear laterad of them and also a transverse series of much shorter bristles near anterior margin; lateral margins with a pair of strong bristles on each segment, including the apical one. Posterior spiracular chamber at apex, fringed with long hairs; abdominal segments 1 to 6 with rudimentary lateral spiracles.

*Diptera Danica, Part I, p. 23. (1907)

†Nat. Hist. Rev., No. III, 1857, p. 194.

‡Diptera Danica, Part I, p. 31. (1907)

HABITS OF LARVAE

The larvae are aquatic, occurring along with and having the same habits as those of *Stratiomyia* and *Odontomyia.*

HABITS OF IMAGINES

The flies are rarely taken except by sweeping amongst vegetation on the margins of streams or ponds, or on marshy ground. I have not found them on flowers. One species I have taken in numbers on the leaves of bracken (*Pteris*) in Europe.

As there is no synopsis of the species of this genus for North America the following key and revision is presented as an aid to students.

Key to Species

IMAGINES

1. Thorax with 2 yellow lines on dorsum in addition to the pair on upper margins of pleurae....................................2
— Thorax with 4 yellow lines on dorsum in addition to the pair on upper margins of pleurae....................................3
2. Femora in part black........................*centralis* (p. 326).
— Femora entirely yellow...................*approximata* (p. 326).
3. Abdomen with a complete yellow fascia on third segment in addition to the usual lateral spots................*variegata* (p. 327).
— Abdomen with at most 3 spots on third segment, one in center and one on each side....................................4
4. Central spot absent from third abdominal segment; legs with black markings; large species, 8 mm.................*crotchi* (p. 328).
— Central spot present on third abdominal segment; legs, with the exception of the coxae, yellow; smaller species, about 5 mm......5
5. Fourth abdominal segment with 2 small spots on center, the lateral pale marks very distinctly curved forward and widely separated; veins surrounding discal cell of wing distinct..*aldrichi* (p. 329).
— Fourth abdominal segment without spots except the laterals; veins enclosing discal cell indistinct..............................6
6. The pale markings whitish; lateral stripes on frons very slightly incurved at upper extremity, not connected there (female).......
..................................*albovittata* (p. 330).
— The pale markings sulphur- or lemon-yellow; lateral stripes on frons distinctly incurved and connected with each other at their upper extremities (female)......................*picta* (p. 331).

Oxycera centralis Loew

Oxycera centralis Loew, Berl. Ent. Zeitschr., Vol. 7, 1863, p. 8.

This species is somewhat similar to *approximata,* differing in having the antennae black, the pleurae immaculate, and the legs, especially the femora, with black markings.

Originally described from Red River of the North, and not subsequently recorded as far as I am aware.

Oxycera approximata, n. sp.

Male.—Glossy black, with lemon-yellow markings. Head black, sides of frons with a silvery line which is connected with one on sides of face, the latter becoming abruptly narrowed on its lower third; mouth parts yellow; posterior eye-orbits silvery; antennae orange, apical joint (6th) and arista brown. Thorax with 2 yellow vittae near lateral margin which extend from humeral spot to suture and slightly beyond, and are occasionally connected with a large irregular spot on posterior lateral angles of disc; another yellow line, connected with the sublateral one by the humeral spot, extends along the upper margin of pleurae to wing-base, where it becomes conspicuously broader; below the expanded posterior portion of the lateral line is a large yellow spot, and slightly caudad of the latter and situated higher on the side is a smaller one; scutellum black, margin narrowly yellow, thorns yellow, blackened at apices. Base of abdomen with a yellow spot which extends laterad anteriorly in the form of a slender line; third segment with a pair of approximate spots on anterior half and an oblong spot on postero-lateral angle; fourth segment with an oblong spot on postero-lateral angle which is smaller than that on the preceding segment; fifth segment with the posterior margin rather broadly yellow; lateral spots usually carried more or less distinctly along the extreme lateral margins of segments; venter black. Legs yellow; coxae black. Wings clear, veins yellowish. Halteres lemon-yellow.

Eyes contiguous; antennae rather short, not longer than arista. Thorax with short brownish discal hairs; scutellar thorns of normal size. Abdomen with rather sparse short pale hairs. Legs normal in structure. Cross vein furcate, the fork forming almost a right angle; the 4 veins leaving discal cell indistinct.

Female.—Differs from the male in having the 2 approximated spots on third abdominal segment smaller and separated, and in the color and structure of the head as follows: frons one third the width

of head, glossy black, a conspicuous yellow line on each side extending from base of antennae somewhat above middle of frons, its upper portion being separated from the eye-margin by a narrow black line; face glossy black, slightly yellowish on each side, and with a conspicuous silvery, pilose, stripe which extends beyond the lower extremity of the yellow line on frons; posterior eye-orbits conspicuously yellow. In other respects as in the male.

Length, 5 mm.

Type locality, Muncie, Illinois, July 5, 1914 (J. R. Malloch). Allotype (male), Lafayette, Indiana, June 23 (J. M. Aldrich).

The type specimen was taken by sweeping vegetation on the bank of Stony Creek. The allotype is in the collection of Prof. J. M. Aldrich; the type, in the collection of the Illinois State Laboratory of Natural History.

This species is closer in general appearance to *centralis* Loew than to any described North American species, but may be readily separated from it by the entirely yellow legs, the greater amount of black on scutellum, and the presence of pleural spots, as well as by other characters.

Oxycera variegata Latreille

Oxycera variegata Latreille, Encycl. Méth., Vol. 8, p. 600. (1811)
Oxycera variegata (Olivier) Macquart, Dipt. Exot., Vol. 1, Pt. II, p. 191. (1838)
Oxycera unifasciata Loew, Berl. Ent. Zeitschr., Vol. 7, 1863, p. 9.

Male.—Black, shining, with conspicuous lemon-yellow marks. Head black; frons with a lateral line of white pilosity which connects with a similar line on sides of face, the latter abruptly narrowed on lower portion; face with 2 yellow spots below bases of antennae; mouth parts yellow; antennae reddish yellow, apical joint (6th) and arista brownish; occiput and anterior eye-orbits black. Thoracic vittae yellow, 4 in number, submedian pair slightly dilated anteriorly, and with a perceptible outward curve, occasionally connected with the sublateral pair, interrupted at suture, the portion beyond suture subtriangular and extending to posterior margin of disc; sublateral vittae broader than submedian pair, slightly dilated anteriorly, at suture, and posteriorly, connected with lateral stripe by humeral spot; pleurae with 2 spots on posterior portion; scutellum black only on extreme anterior margin and apices of thorns. Abdomen black; a large oblong spot on base of dorsum, a small lateral spot on sides of second segment, a complete fascia (which is slightly emarginate on posterior margin) on third segment, a large oblong spot on fourth

segment, and the greater portion of fifth segment yellow, these markings being connected by means of a narrow yellow marginal line; venter with a conspicuous oblong yellow spot on lateral margins of each segment. Coxae black, legs yellow. Halteres yellow.

Eyes contiguous; antennae short, barely longer than arista. Thoracic hairs yellow, particularly noticeable on anterior central portion; scutellum shorter than the thorns. Legs normal. Fork of third vein at right angles to that vein; the 4 veins leaving discal cell indistinct.

Female.—Differs from the male in the color and structure of the head as follows: frons glossy black, about one third the head-width, almost parallel-sided, in profile distinctly higher than eyes, a more or less distinct suture or depression visible on center, a rather broad yellow line on each side, extending from a short distance above the antennae to the anterior ocellus, dilated at its lower extremity, where it almost touches the eye-margin, of nearly uniform width throughout the remainder of its length, and separated from the eye-margin by a space equal to its own width, the space between slightly increased at the upper extremity; face as in male but the yellow spots larger; posterior eye-orbits yellow, blackened slightly below and separated from the large yellow vertical spot by a narrow black line. In other respects as the male.

Length, 3.5–4 mm.

Originally described from Carolina. Loew described the same species, under the name *unifasciata*, from Pennsylvania. Melander has recorded *unifasciata* from Virginia and Illinois. I have seen specimens from Monticello, Illinois (Hart and Malloch) and Lafayette, Indiana (J. M. Aldrich), taken in June and July.

Oxycera crotchi Osten Sacken

Oxycera crotchi Osten Sacken, Western Diptera, p. 212. (1877)

Original description: "*Oxycera crotchi* n. sp., ♀.—Abdomen with three lateral yellow spots on each side and an apical triangular one, all connected by a narrow yellow margin; femora black, with yellow tip; tibiæ and tarsi yellow. Length 8 mm.

"*Female.*—Face and front yellow, with a broad black stripe in the middle; posterior orbits yellow; vertex, cheeks under the eyes, and occiput black. Antennæ: basal joints black (the rest wanting). Thorax black, opaque; a yellow stripe from the humerus to the antescutellar callus is interrupted a little beyond the middle, a pair of nar-

rower yellow stripes on the dorsum slightly expanded in front and not reaching beyond the transverse suture; scutellum yellow, the base black; pleuræ with a large yellow spot in front of the wings, and a smaller oblong one under it; the black opaque abdomen has a subtriangular yellow spot on each side of the second segment, a larger, semi-elliptical spot on each side of the third segment, a somewhat similar, but smaller, pair of spots on the fourth segment, a large triangular spot on the last segment; all these spots are connected by the narrow, yellow, abdominal margin; ventral segments yellow in the middle, brownish black on the sides. Femora black with yellow tips; tibiæ and tarsi yellow; joints 3 or 4 of front tarsi darker. Wings tinged with yellowish anteriorly, with grayish posteriorly; stouter veins and stigma reddish yellow.

"Hab.—California (G. R. Crotch). A single specimen."

This species may belong to the genus *Euparyphus*; the third joint of the antennae—the best character for the separation of the genera—was missing from the type. I have not seen any specimens either of *Oxycera* or *Euparyphus* that agree entirely with Osten Sacken's description, though two males of a species of *Euparyphus* in Professor Aldrich's collection from Idaho and Colorado agree fairly well with it. The submedian yellow thoracic vittae do not extend much beyond the suture in these specimens, but the third vein is unforked—a character that it is improbable Osten Sacken would overlook. The length given for *crotchi*, 8 mm., exceeds that of any other member of the genus *Oxycera* from North America.

Originally described from California and not subsequently recorded.

Oxycera aldrichi, n. sp.

Male.—Black, shining, with lemon-yellow markings. Head black; face with a white pollinose line on lateral margins which extends along the sides of frons, and 2 yellow spots below bases of antennae; antennae apically brown; mouth parts yellow. Thorax with the same yellow markings as in *variegata*. Abdomen with the following yellow markings: a large basal spot which is slightly narrowed posteriorly, a larger similarly shaped transverse spot on middle of third segment, a pair of minute rounded submedian spots on fourth segment, a large subtriangular spot on fifth, a small lateral spot on second, a large anteriorly curved one on lateral margins of third and a narrower similarly curved one on fourth; venter black, the lateral margins yellow. Coxae black, legs reddish yellow. Wings clear, veins yellow. Halteres lemon-yellow, stems reddish.

Structurally as the male of *variegata,* but the veins enclosing the discal cell are much more distinct.

Length, 4.5 mm.

Type locality, Lafayette, Indiana, June 23 (J. M. Aldrich).

Named in honor of the collector.

Oxycera albovittata, n. sp.

Female.—Black, shining, with conspicuous whitish markings. Head black; frons with a white line on each side from anterior ocellus to antennae, touching the eye-margin on the lower third and separated from it on the upper two thirds by a space subequal to its own width, not incurved above, connected with the white, pilose lateral face-stripe at base of antennae, the latter not abruptly narrowed below, gradually tapering; face with the exception of the lateral lines black; posterior orbits white, except a portion along eye-margins on upper half, separated from the white spot on vertex by a narrow black line; mouth parts whitish yellow; antennae reddish, basal two joints whitish, apical joint brown. Thorax with the same pale markings as *variegata*; base of scutellum and basal angles black. Abdomen with the following creamy white markings: a transverse spot at base, produced caudad in center, a moderately large oblong spot on center of third segment which is rounded posteriorly, the entire apical half of fifth segment, and a spot on lateral margins of second, third, and fourth segments, all of the marginal spots connected by means of the narrow marginal whitish line, the spot on each side of third segment larger than the others; venter black, marginal spots showing slightly. Coxae black, legs flavous. Wings clear, veins yellow. Knob of halteres white, stem brownish. Hairs on body whitish.

Frons slightly broader than eye-width, slightly raised on each side of the median line, this line and the lateral edges slightly impressed; antennae rather elongate, arista not longer than the composite third segment (3–6); posterior orbits rather broad. Thorax distinctly punctured, discal hairs rather short. Abdomen and legs of normal form. Vein closing apex of discal cell in vertical line with apex of stigma; the portion of costa from apex of stigma to fork of third vein distinctly longer than that from fork of third vein to apex of third.

Length, 5 mm.

Type locality, Muncie, Illinois, July 5, 1914 (J. R. Malloch).

Oxycera picta Van der Wulp

Oxycera picta Van der Wulp, Tijdschr. v. Entom., Vol. 10, 1867, p. 133.

A male which I believe belongs to this species differs from the foregoing description in having the pale markings lemon-yellow and considerably larger. The antennae are shorter, not exceeding the length of the arista, and the entire length of the specimen is 5.5 mm.

Locality, Urbana, Illinois, June 7, 1901 (C. A. Hart).

Van der Wulp had some doubts as to the identity of his species with that described by Latreille as *maculata,* since many essential characters were not mentioned by that author, and Macquart in his redescription of the type did not make matters much better. From *albovittata* the female of *picta* may be separated by the sulphur-colored markings, and by the fact that the lateral frontal stripes curve inwards above and connect with each other and with a pale line round the ocelli. It is possible that Van der Wulp had two species mixed, as he says that there are sometimes 2 yellow spots below the antennae—a character that I am inclined to believe is not by any means variable, and one which is absent from the male described above. *Picta* was originally described from Wisconsin. Melander has recorded *maculata* from Louisiana, but the record may refer to *picta.*

Subfamily BERIDINAE

I have not seen the larva of any species of this subfamily. My only information as to the characters of this stage is derived from European authors, and is included in the key to the subfamilies of Stratiomyiidae.

The larvae are terrestrial in habit. In general appearance they resemble those of Geosargus, but differ in having the bristles on the dorsum and lateral margins short and closely placed in groups of 4 or more.

The imagines are very rarely met with in North America—a fact quite in contrast with conditions in Europe, where several species are among the very commonest of any in the family.

Subfamily GEOSARGINAE

This subfamily contains nine distinguishable genera. Williston gives ten in his "Manual", but there is no valid reason for separating *Macrosargus* from *Geosargus.* I have obtained the larvae of two genera, which are described herewith.

SUBFAMILY CHARACTERS

Larva and Puparium.—Head elongate; antennae distinct but short. Body broad, almost parallel-sided, slightly narrowed anteriorly, rounded posteriorly, with distinct vittae; segments distinct; dorsal segments with a transverse series of 6 strong bristles; lateral margins of each segment except the apical one with 2 bristles; ventral segments with bristles similar to but weaker than dorsal series, spiracular chamber transverse, situated on disc of apical segment near apex; apical segment with a number of long marginal hairs and a few on disc.

Imago.—Antennae short, with an apical or dorsal arista; abdomen with 5 or 6 visible segments; discal cell emitting 3 veins.

KEY TO GENERA

LARVAE

1. Pale stripes on disc of dorsal segments geniculated on each segment .... *Geosargus.*
— Pale stripes on disc of dorsal segments straight....... *Microchrysa.*

GEOSARGUS Bezzi

This genus is synonymous with *Sargus* of Aldrich's Catalogue, *Sargus* Fabricius being preempted by *Sargus* Walberg.

GENERIC CHARACTERS

Larva and Puparium.—The larva differs from that of *Microchrysa* in the shape of the head, which is much shorter in comparison with its width than in that genus.

Imago.—Brilliant metallic blue or green flies, with slender bodies and unspined scutellum.

HABITS OF LARVAE

The larvae are scavengers, feeding on decaying vegetation and manure.

HABITS OF IMAGINES

Commonly found on leaves of trees and bushes, especially if in the sunshine, and particularly on such trees or bushes as border pastures.

One species, *nubeculosus* Zetterstedt, was introduced into North America from Europe. It has been recorded as feeding in the larval stage on decaying turnips and other root-crops.

Geosargus viridis Say

Sargus viridis Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 87.

Larva and Puparium (Pl. XLVIII, Fig. 16).—Length, 9 mm.; width across dorsum at middle, 3 mm. Brownish testaceous, dorsal surface with a dark grayish brown, slightly irregular, waved stripe on each side of the middle line, the area laterad of the line occupied by 2 rather less distinct stripes of the same color, which are slightly fused and irregular, the whole dorsum having the appearance of being six-striped, the median pair of stripes more or less distinctly connected near anterior margin of each segment and enclosing 2 small spots near posterior margin, the ventral surface similarly marked. Head with only 2 brown dorsal lines; tips of maxillary palpi, mandibles, and antennal base dark brown.

Head slightly longer than broad, armed as in Figure 8, Plate XLVIII; surface of thoracic and abdominal segments finely shagreened (Fig. 16, *b*), the armature as shown in the same figure; spiracular depression in the form of a deep transverse slit, situated very close to apex of segment; ventral segments with armature similar to that of dorsal; apical ventral segment as in Figure 12.

Described from examples obtained in cow manure at Muncie, Ill., in April, 1916. The larvae are very sluggish. The first example of the imago emerged in the laboratory a month after being brought in from the field.

The species is common everywhere in Illinois, and in fact all over the United States.

Geosargus sp.?

I have before me a number of larvae of a species of *Geosargus* that differ from *viridis* in having the head longer—more resembling that of *Microchrysa polita*—and also in the striping of the dorsum, the central dark stripe consisting of a series of diamond-shaped spots—one on each segment—instead of a divided stripe as in *viridis*. In other respects the larvae agree closely.

I have a suspicion that the color of these specimens may not be that of fully matured larvae, as they had previously undergone very considerable changes, being whitish testaceous and without distinct vittae and almost devoid of bristles when young, developing the vittae and bristles as they matured. If they had overwintered safely they might have assumed the coloring and structure which would have proven them to be *viridis*, but as it is I can not definitely decide their specific status.

The species was obtained by me at White Heath, Ill., June 24, 1916, from horse dung.

MICROCHRYSA Loew

GENERIC CHARACTERS

Larva and Puparium.—Very similar to the larva of *Geosargus,* differing as indicated in generic key, and in having a longer head.

Imago.—Brilliant metallic blue species, with rather stout bodies.

HABITS OF LARVAE

The larvae feed upon manure or decaying vegetation. The species hibernate as larvae.

HABITS OF IMAGINES

The flies have similar habits to those of *Geosargus.*

MICROCHRYSA POLITA Linné

Musca polita Linné, Fauna Suecica. (1761)

Larva and Puparium.—Length, 5–6 mm. Differs from *Geosargus viridis* in having the two pale stripes on dorsum entirely straight and the central dark line complete.

Head more slender anteriorly than in *G. viridis* (Pl. XLIX, Fig. 2). Armature similar to that of *viridis* except that the bristles are much longer. Apical segment more attenuated apically than in *Geosargus,* the respiratory opening much smaller, not in the form of a transversely elongated slit, and farther from apex than in that genus (Pl. XLIX, Fig. 3).

Described from specimens from which imagines were obtained by the writer. The larvae were found in company with those of *Geosargus viridis* in cow manure at Muncie, Ill., in April, 1916. They closely resemble the larva of *Geosargus,* but the difference in the dorsal markings readily separates the two.

The imagines are not nearly so common as those of *Geosargus viridis.*

Subfamily PACHYGASTERINAE

I recently published a revision of the imagines of this subfamily*, and students may refer to that for full information regarding species.

*Ann. Ent. Soc. Amer., Vol. 8, 1915, pp. 305–320.

The present paper deals only with the early stages and additional data bearing upon the occurrence of Illinois species.

SUBFAMILY CHARACTERS

Larva and Puparium.—Very similar in general appearance to the larvae of Geosarginae; but all species that I have seen, differ in having no distinct color-markings on dorsum, the body being uniformly testaceous or brownish. The head is also noticeably more elongated and the body narrower in comparison with its length. The armature of the body varies throughout the subfamily, but the bristles are always conspicuous—though sometimes of unequal length—the surface is shagreened as in other subfamilies, and there are no evident decumbent hairs. The apical segment is similar to that of Geosarginae. The lateral abdominal spiracles are very small, or indistinguishable.

Key to Genera

LARVAE AND PUPARIA

1. Abdominal bristles very long, those on lateral margins, and on posterior margin of apical segment particularly so, the latter of uniform length and as long as or nearly as long as width of segment..2
— Abdominal bristles short, those on margin of apical segment not more than half as long as width of segment, some of them very short....................................*Neopachygaster.*
2. Outer bristle of each transverse series on dorsal abdominal segments minute, not more than a sixth as long as next bristle, the latter very much longer than inner pair.........*Eupachygaster.*
— Outer bristle of each transverse series on dorsal abdominal segments about half as long as next bristle, the latter not very much longer than inner pair...............................*Zabrachia.*

Neopachygaster Austen

I have before me a large series of larvae and empty puparia of *maculicornis* Hine, the only species in North America so far assigned to this genus.

GENERIC CHARACTERS

Larva and Puparium.—Head very much longer than its greatest width, much tapered anteriorly; antennae very short; surface hairs long. Body narrower than in *Zabrachia* and *Eupachygaster*, the bristles comparatively shorter.

Neopachygaster maculicornis Hine

Pachygaster maculicornis Hine, Ohio Nat., Vol. 2, 1902, p. 228.

Larva and Puparium.—Length, 3–4 mm. Pale testaceous, unmarked.

Head similar to that of *Eupachygaster henshawi* in general appearance, the bristles noticeably shorter. Armature of body similar in arrangement to that of *henshawi* but the bristles much shorter, their relative lengths on penultimate and ultimate segments as in Figure 6, Plate XLIX.

The larvae of which the foregoing is a brief description, were obtained under the bark of fallen elm-trees at White Heath, Ill., in March and April, 1916. I reared a large number of imagines from the larvae, and have also many of the latter alive in the laboratory now (January, 1917) which I took under similar conditions in the forestry of the University of Illinois October 21 and 28, 1916. The larvae feed upon decaying matter under the slightly loosened bark, but also, occasionally, on other dipterous larvae—as on those of *Lonchaea polita,* which are found along with them. *Lonchaea* larvae often eat other larvae and puparia—as do also those of *Euxesta,* which frequents the same habitat—in fact the dipterous larvae found under bark under conditions suitable for Stratiomyiidae appear to be almost without exception alternately predaceous or saprophagous. They may be able to live entirely upon the sap and slightly decayed vegetable matter under the bark but I suspect that the main food supply consists of excreta, exuvia, or the bodies of coleopterous larvae that occur there. That they feed upon each other I have proven by personal observation.

Eupachygaster Kertész

I obtained a single larva of this genus under the loose bark of an apple-tree at Savoy, Ill., May 4, 1916, from which I succeeded in rearing a female imago. A comparison of the larva when found with a figure of that of *Eupachygaster tarsalis* Zetterstedt convinced me that I had one that was congeneric with that species, and as I had provisionally placed but one North American species in that genus I was particularly anxious to discover whether my diagnosis of the imagines was correct. I was therefore much gratified to find that the resultant imago agreed generically with the species I had placed in this genus.

I subsequently obtained many larvae of the genus at Urbana, most of which are still alive (January 1917).

GENERIC CHARACTERS

Larva.—Head elongate, tapering anteriorly, the portion anterior to eyes distinctly longer than its greatest breadth; surface hairs long. Segments of body well differentiated; each dorsal segment with 6 hairs in a transverse series beyond middle, the outer one on each side very short, the middle one very long, and the inner shorter than the latter but much longer than the outer; lateral margin of each segment with a pair of hairs, the anterior one very short, the posterior one very long; hairs on apical segment long and equal, the segment rounded posteriorly; ventral segments, excepting the apical one, each with 6 subequal hairs in a transverse series.

Imago.—Antennae short, third joint disc-like; arista very short-haired; eyes large, with vertical color-bands, those of the female rather widely separated, those of the male narrowly so. Thorax with decumbent silvery pile; scutellum with a posterior marginal ridge. Abdomen short, rounded, subglobose. Third vein of wing furcate.

HABITS OF LARVAE

The larvae are found under bark of trees that has become slightly loosened. They feed upon the sap and upon insect larvae and are very sluggish.

HABITS OF IMAGINES

The flies frequent leaves of trees in the sunshine, and are very deliberate in their movements, walking slowly, but they take flight suddenly, though they fly rather heavily as compared with most members of the subfamily.

I know of no parasites of any stage in this genus.

Key to Imagines

1. Arista with very dense whitish pubescence which gives it the appearance of being thickened; third antennal joint disc-like; scutellum not regularly convex on disc, the center with a slight hump; pile on sides of mesonotum arranged in small punctiform groups .... *punctifer.*

— Arista with very little pubescence, appearing filiform; third antenal joint much higher than long; scutellum regularly convex on disc; pile on sides of mesonotum arranged in irregular short stripes .... *henshawi.*

Eupachygaster punctifer Malloch

Eupachygaster punctifer Malloch, Ann. Ent. Soc. Amer., Vol. 8, 1915, p. 316.

The eyes are marked and colored as in *henshawi* except that the anterior margin does not have a distinct stripe and that the other stripes are broader, the violaceous blue one continuing almost to the lower margin. The thorax has a central narrow stripe of silvery pile, the lateral portions of the disc being adorned with punctiform groups of similar pile. The basal half of the abdomen is devoid of punctiform groups of silvery pile.

This species was described from a single female specimen taken by Dr. Nason at Algonquin, Ill., which bears no date of capture.

The other specimen referred to in the notes on this species given under the original description belongs to the next species. I took a female example of *punctifer* in a wood near an old orchard at White Heath, Ill., June 24, 1916.

Eupachygaster henshawi, n. sp.

Larva.—Length, 7 mm. Dark brown, shining, head and lateral margins of segments paler.

Head as in Figures 4 and 5, Plate XLIX; antennae small, pointed, located on disc well back from lateral margin; dorsal and ventral armature as in figures. Armature of dorsum of thorax and abdomen as in Figure 9 (puparium); thoracic segments on their ventral surface with 6 hairs in a transverse series, the outer two on each side of each segment contiguous basally; ventral abdominal segments each with a transverse series of 6 long hairs, the outer one on each side of each series longer than the others, each series occupying about half the width of segment; anal opening elongate, with 2 short hairs on each side close to margins of the opening; disc of apical segment with 2 long hairs, one on each side before middle and about midway from anal opening to lateral margin. All hairs microscopically pubescent.

Imago; Female.—Black, very distinctly shining. Frons and face shining black, the center of former slightly obscured by the presence of a number of piliferous punctures; a conspicuous stripe of silvery pile, beginning above antennae on lateral margins of frons, extends down over sides of face to lower margin of eyes; antennae yellow, the inner sides of first 2 rings of third joint glossy reddish brown; arista whitish; eyes with 4 vertical dark stripes, one on center, deep violaceous blue, extends from upper margin to a point one fifth distant from lower margin, the others (purple) being a slender one along

anterior margin, a broad one extending from lower margin almost to upper margin between the former and the blue central stripe, and a rather broad one along posterior margin. Thorax glossy black, the disc very densely punctate, so that it appears less glossy than the sides; center of disc with a narrow line of silvery pile which extends posteriorly to the diagonal median sutures, the latter with similar silvery pile; sides of mesonotum with silvery pile which is arranged in short irregular stripe-like groups anteriorly, and rather evenly on the entire surface posteriorly; scutellum without silvery pile. Abdomen slightly shining, the surface with piliferous punctures, the hairs slender and rather sparsely and regularly arranged. Legs yellowish white, coxae, trochanters, and femora except their extreme apices, shining black. Wings hyaline, veins pale yellow. Halteres brown, knobs white.

Frons about one fourth the width of head, distance from upper extremity of lateral silvery stripe to anterior ocellus greater than its width at former point; antennae larger than in *punctifer*, third joint higher than long; arista slender, hair-like; antennae inserted below middle of eye, in profile. Scutellum more elongate and less abruptly humped than in *punctifer*. Abdomen differing from that of *punctifer* in the absence of the punctiform groups of silvery pile.

Male.—Three male specimens which I have reared differ from the female in having the eyes much closer above, the distance between them not exceeding one tenth the width of head, the antennae smaller and with the third joint conspicuously browned apically, and the eye with only 2 vertical purple stripes—one along anterior margin and the other just proximad of middle, the latter not extending to lower margin. In other respects the sexes agree very closely.

Length, 4 mm.

Type from Savoy, Ill., May 4, 1916, larva under loose bark of apple-tree; imago emerged June 17, 1916. Paratypes from Urbana, Ill., October 21, 1916, larvae under bark of felled elm-tree; imagines emerged December 29, 1916 and January 5, 1917.

I have pleasure in dedicating this species to Mr. Samuel Henshaw, of the Cambridge (Mass.) Museum of Zoology, who kindly submitted the material in that collection for examination when I wrote the paper containing the description of *punctifer*.

There is a specimen of *henshawi* in the Cambridge collection about the sex and identity of which I had some doubt when I examined it. It agrees in every respect with the female now before me.

It seems worth mentioning that while the eyes of both of the above species have vertical color-stripes, *Pachygaster pulcher* has 4

slender horizontal stripes on center, and *Neopachygaster maculicornis* has the upper half of eye, except the narrow posterior margin, purple, the remainder being yellowish.

ZABRACHIA Coquillett

There is only one species of this genus recorded for North America.

GENERIC CHARACTERS

Larva and Puparium.—Similar in general appearance to that of *Eupachygaster henshawi,* differing as stated in key to genera.

ZABRACHIA POLITA Coquillett

Zabrachia polita, Coquillett, Bull. 47, N. Y. State Mus., p. 585. (1901)

Larva and Puparium.—Length, 3.5–4.5 mm. Dark reddish brown. Head as in *Eupachygaster,* the bristles longer than in *Neopachygaster.* Arrangement of bristles on body as in the other genera of the Pachygasterinae, but their relative lengths different. The large lateral abdominal bristle in *Zabrachia* is not nearly as long as width of abdomen, while in *Eupachygaster* it is quite as long as the segment which bears it. The other distinctions are indicated in the key to genera.

I have ascertained the above facts from an examination of a specimen spent me by C. W. Johnson, from Massachusetts.

Subfamily XYLOMYIINAE*

Williston places the genus *Xylomyia* in his subfamily Arthroceratinae, along with the genera *Glutops* and *Arthrocera.* His note on page 387 of his Manual would appear to indicate that he considered *Misgomyia* as belonging to the same subfamily. None of the three genera which he includes with *Xylomyia* are known to me. If they belong to the same subfamily as *Xylomyia* the name of the subfamily should be Xylomyiinae, unless one accepts *Solva* Walker as a prior name for the genus *Xylomyia.*

XYLOMYIA Rondani

I have seen the larva of but one species of this genus. It agrees generally with that of *Xylomyia maculata* Meigen as figured by

*I have retained the name *Xylomyia* here though the evidence that *Solva* Walker has priority is very strong.

Verrall*, but differs noticeably in having two hairs instead of six on the dorsum of the thoracic and abdominal segments. It is quite probable that *pallipes* is not congeneric with the other species, good characters existing in larvae and pupae which may be used for their separation.

When emerging the imago withdraws the pupal skin either largely or entirely from the puparium. No other genus of Stratiomyiidae known to me does this. The pupa closely resembles that of Xylophagidae.

GENERIC CHARACTERS

Larva.—Head large, posteriorly retracted within prothorax; antennae sessile; maxillae with slender transverse ridges. Thorax and abdomen with a few strong hairs on each segment. Prothoracic spiracles large. Anal spiracles separated, situated in a terminal chamber the margins of which protrude lip-like.

I give a synopsis of the imagines of the North American species of *Xylomyia* as the only available ready means of identifying them. The key presented may prove useful to students and save valuable time otherwise required to look up isolated descriptions.

KEY TO SPECIES

1. Hind femora spinose beneath............................*pallipes.*
— Hind femora unarmed....................................2
2. Coxae black..*parens.*
— Coxae in large part yellow..............................3
3. Thorax with 2 well-defined yellow vittae on disc........*americana.*
— Thorax without well-defined vittae......................4
4. Hind femora entirely black.........................*aterrima,* ♀.
— Hind femora wholly or largely yellow......................5
5. Pleurae entirely black; hind femora reddish yellow.............
....*pallidifemur,* ♀.
— Pleurae partly yellow....................................6
6. Halteres yellow with a brown spot at base of knobs; antennae black
....*aterrima,* ♂.
— Halteres yellow; antennae reddish on inner side................7
7. Hind coxae blackened in front; hind femora reddish yellow; eyes separated by less than one sixth the head-width; furcation of fourth and fifth branches of radius distinctly distad of a line drawn from apex of third branch of that vein to point of furcation of first and second branches of media......*pallidifemur,* ♂.

*British Flies, Vol. 5, p. 36. (1909)

— Hind coxae yellow; hind femora darkened on apical third; eyes separated by more than one fifth the head-width; furcation of fourth and fifth branches of radius distinctly proximad of, or in line with, a line drawn from apex of that vein to point of furcation of first and second branches of media......*tenthredinoides.*

Xylomyia pallipes Loew

Subula pallipes Loew, Berl. Ent. Zeitschr., 1863, p. 6.

Larva.—Length, 7–9 mm. Dark brown, head and thoracic segments yellowish, the latter darkened on sides and posteriorly.

Protruded portion of head slightly longer than prothorax, the dorsal surface with several strong hairs (Pl. XLVIII, Fig. 15), labrum conically produced, the apex very sharp (Pl. XLVIII, Fig. 4); mandibles recurved, slightly dentate; maxillae prominent, their ventral surfaces with numerous narrow transverse ridges, palpi inconspicuous (Pl. XLIX, Fig. 7); labial plate as in Figure 10, Plate XLIX; antennae sessile; eyes distinct but not protruded; ventral surface of head with a long hair on each side in transverse line with the eyes. Surfaces of thoracic and abdominal segments finely shagreened excepting a large irregular area on dorsum of prothorax, a narrow transverse area on ventral surface of same segment, a pair of narrow transverse plates on dorsum of metathorax, and the tubercles on the various segments. Prothoracic spiracle with 3 openings (Pl. XLVIII, Fig. 9). Abdominal segments 2–7 each with a transverse series of small round warts near anterior margin on dorsum; eighth segment with 7 rather large warts in an irregular (2, 3, 2) transverse series proximad of median line, posterior lateral angle with 2 small warts; all ventral segments with a closely placed series of small warts on their anterior margins; anal opening slightly T-shaped, the margins toothed; spiracles distinctly separated, situated within an apical chamber whose margins protrude lip-like from apex of eleventh segment and appear like an additional segment; thoracic and abdominal segments, except the apical one, each with 6 hairs, one on each lateral margin and one on each side on venter and dorsum; apical segment as in Figure 14, Plate XLVIII.

This description was drawn from larvae obtained by me October 21, 1916, under the bark of trees which had been felled in the spring of the same year. The bark was beginning to loosen, and larvae of *Euxesta, Lonchaea,* and *Heteromeringia* were abundant under it. The Xylomyia larvae were found to be predaceous, feeding indiscriminately upon the other larvae. They have a peculiar habit of raising up the thoracic segments when disturbed, but are very sluggish.

This species is undoubtedly the commonest of the genus. It was originally described from Illinois and Wisconsin, and has since been recorded from Montana, southern California, Colorado, New Jersey, and "the Atlantic States". It occurs commonly on tree-trunks in June, July, and August throughout Illinois.

Townsend has described the puparium and pupa, and given a brief account of the habits of the species*.

Xylomyia parens Williston

Subula parens Williston, Can. Ent., Vol. 17, 1885, p. 122.

Described from Washington State and not subsequently recorded.

Xylomyia americana Wiedemann

Xylophagus americanus Wiedemann, Dipt. Exot., Vol. 1, p. 51. (1821)

This species was originally described from "North America." It has since been recorded from Mexico, Illinois, and Pennsylvania. I have before me an example from Urbana, Ill., taken June 17, 1916, on a window, and one bearing the label N. Ill., which, I am informed, stands for Algonquin or vicinity.

Xylomyia aterrima Johnson

Xylomyia aterrima Johnson, Ent. News, Vol. 14, 1903, p. 24.

This species was originally described from examples from northern Illinois and Fredonia, N. H.

It is unrepresented in our Laboratory collection.

Xylomyia pallidifemur n. sp.

Male.—Head brownish black; 2 spots above bases of antennae and the face whitish pilose; antennae blackish brown, reddish on inner side of basal half; proboscis and palpi yellow. Thorax reddish brown, blackened behind humeri, above bases of wings, in front of scutellum, on a vertical area on anterior half of mesopleura and sternopleura, on the greater portion of the hypopleura, and at the center of postnotum; yellow marks cover the whole of humeri, both sides of the transverse suture narrowly, all of the pleurae except the black portions, and the center of scutellum. Abdomen reddish, the dorsum more or less infuscated. Legs pale yellow, hind pair more reddish yellow; anterior

*Ent. News, Vol. 4, 1893, p. 163.

surface of hind coxae and apical 4 joints of hind tarsi fuscous. Wings clear, veins pale brown. Halteres reddish yellow.

Eyes separated by about one seventh the head-width; antenna about 1½ times as long as height of head, the flagellum slender, apical joint as long as preceding 2 together. Thorax and abdomen with short hairs. Wing venation similar to that of *americana,* as indicated in key.

Female.—Differs from the male in having the pleurae entirely black, and the apex of abdomen deep black.

The wing venation differs slightly from that of the male, the furcation of radius being but little distad of a line drawn from apex of third branch of radius to point of furcation of first and second branches of media.

Length: male, 11 mm.; female, 13 mm.

Type locality, Urbana, Ill.; 1 male, June 17, 1890; 2 females, June 1 and 2, 1890,—(C. A. Hart).

Xylomyia tenthredinoides Van der Wulp

Subula tenthredinoides Van der Wulp, Tijdschr. v. Ent., Vol. 10, 1867, p. 132.

This species was originally described from specimens obtained from Wisconsin. It has since been recorded from Illinois and Pennsylvania. There are specimens in our collection here from Algonquin, Urbana, St. Joseph, Augerville, and Grand Tower,—Illinois, all taken in June of various years.

Stratiomyiid Larvae of Uncertain Generic Location

Genus incertus 1

Larva (Pl. XLIX, Fig. 11).—Length, 7 mm. Pale grayish brown.

Head rather long, tapered anteriorly; maxillae armed with numerous curved hairs apically; antennae long and slender, apical joint short and stout. Body broad, the surface covered with fine hairs (not shown in figure except along lateral margin); each segment with very weak bristles arranged in tranverse series much as in Pachygasterinae. Lateral margins of each abdominal segment except the apical one divided into two lobes, the anterior one slender and acute, the posterior one much broader and obtuse; lateral abdominal spiracles rudimentary; a number of short bristles surrounding bases of the larger

ones composing the transverse series on abdominal segments; apical segment with a conspicuous fringe of long soft hairs; respiratory chamber preapical, rather wide centrally.

Described from a specimen obtained in woods at Urbana, Ill., April 30, 1887 (C. M. Weed).

This specimen differs so strikingly from any previously described stratiomyiid that I do not feel justified in suggesting its location in the family.

Genus incertus 2

Larva.—Length, 12 mm. Yellowish brown.

Head very similar to that of *Hermetia,* the hairs on anterior portion and the antennae short. Body of a more uniform width than in *Hermetia,* not broadened apically. Thoracic segments with 2 long and 2 or 4 short bristles in a nearly straight transverse row on dorsum, and a group of 2 to 4 bristles on a common base on each side of venter. Abdominal segments except apical one each with 4 rather weak bristles close to posterior margin and 2 very long and strong ones near anterior margin; as shown in Figure 8, Plate XLIX; ventrally, the series of 6 bristles nearly straight on each segment and the median two weaker than the others; lateral bristles and dorsal armature of apical segment as in above figure; venter of apical segment with 4 bristles on a distinct ridge proximad of anterior extremity of anal opening, the latter fringed with short upright scales; a series of 4 long bristles distad of posterior extremity of anal opening.

Described from a specimen obtained by C. A. Hart in the nest of a cactus rat at Brownsville, Texas, December 1, 1910.

Genus incertus 3

Larva.—Length, 4.5 mm. Yellowish testaceous.

Head long, tapering anteriorly; antennae short; maxillae fringed anteriorly and rather conspicuous; most of the surface bristles tapering, the one above posterior margin of eye slightly clavate. Body parallel-sided, the surface shagreened and covered with minute scales, each segmental incision marked by a double series of small black dots, and several similar dots on each segment laterally. First thoracic segment with the usual 2 transverse series of bristles on dorsum, the others with a single series of 6 each which are, like those of the abdomen, distinctly clavate; ventral surface of each segment with 6 slightly clavate bristles in almost straight transverse series. Abdominal segments with a single clavate bristle on each lateral margin, 6

such bristles on dorsum, and 6 on venter, the latter series not straight and the median two much more widely separated than the others, the outer one on each side considerably proximad of the others and less noticeably clavate; apical segment with dorsal armature as in Figure 1, Plate XLIX; the anal opening unfringed; respiratory chamber small, the opening oval.

The foregoing description was made from a specimen submitted along with a larva of *Microchrysa polita*, and under the same name, by J. A. Hyslop, from Hagerstown, Md. The label indicates that the larvae were feeding upon an arctiid pupa.

Principal Papers on North American Stratiomyiidae

Hart, C. A.

'95. On the entomology of the Illinois River and adjacent waters. Bull. Ill. State Lab. Nat. Hist., Art. VI, 4: 247–266.

Johnson, C. W.

'95. Review of the Stratiomyiae and Odontomyiae of North America. Trans. Am. Ent. Soc., 22: 227–278.

Malloch, J. R.

'15. A revision of the North American Pachygasterinae with unspined scutellum. Ann. Ent. Soc. Amer., 8: 305–320.

Melander, A. L.

'03. A review of the North American species of *Nemotelus*. Psyche, 10: 171–183.

Family *XYLOPHAGIDAE*

There can be no doubt that the species herein included should constitute a distinct family. The larvae differ from those of Stratiomyiidae and Leptidae in many respects, and the pupae also are sufficiently distinct to entitle them to rank in a distinct family.

Without a knowledge of the immature stages of *Rhacicerus* and *Arthropeas* I do not think it advisable to give a definite opinion on their family status. Brauer in 1882* placed them in Xylophagidae on characters possessed by the imagines. By the use of the same characters he placed *Xylomyia* (*Subula*) also in this family, but subsequently, in the same publication (1883), he transferred it to Stratiomyiidae because of the characters of the early stages. It will probably be best to retain the two genera in question in Xylophagidae pending further knowledge as to their early stages. Brues and

*Denkschr. k. Akad. Wissensch. Wien, math.-naturw. Cl., Vol. 44, p. 86.

Melander have placed *Arthropcas* in Stratiomyiidae and *Rhacicerus* in Xylophagidae in their recent book*, using the adult characters as their criteria.

FAMILY CHARACTERS

Larva.—Head not retractile, the exposed portion in the form of a chitinized cone, from a small apical opening in which the mandibulate portions are extruded; several strong hairs on dorsum. Dorsum of some of the thoracic segments chitinized entirely or in part, usually in the form of 3 plates; prothoracic spiracle large. Abdominal segments with locomotor spines in transverse series; apical segment obliquely truncated, the apex heavily chitinized, and with 2 backwardly projecting processes on lower margin; spiracles large, rounded, widely separated, situated above middle of the chitinized plate. Thoracic and abdominal segments each with a number of strong hairs.

Pupa.—Head without thorns except sometimes one on base of each antennal sheath, the latter separated from surface of head, elongate, directed almost straight laterad, their apical portions rounded in cross-section and distinctly annulated. Thorax with marginal series of punctures along the sutures; wings extending to apex of first abdominal segment; apices of hind tarsi extending to or very slightly beyond apices of wings. Abdominal armature increasing in strength from second segment to apical one, almost absent on basal; apical segment ending in a bifid tubercle.

Imago.—The species are very closely allied to those of Leptidae, but may be readily separated from the latter by the structure of the antennae, as indicated in the synoptic key to families of Brachycera.

LARVAL AND IMAGINAL HABITS

The larvae as far as known live under bark or in earth and feed upon larvae of other insects. The imagines are found generally in woods, and as far as I have observed feed upon nectar of flowers and sap or other liquid matter.

XYLOPHAGUS Meigen

KEYS TO SPECIES

LARVAE

1. First and second thoracic segments chitinized dorsally...... *lugens*.
— First, second, and a large portion of third thoracic segments chitinized dorsally.................................... *abdominalis*.

*Key to the Families of North American Insects, p. 64. (1915)

PUPAE

1. Antennal sheath with a thorn at base....................*lugens.*
— Antennal sheath without a thorn at base............*abdominalis.*

IMAGINES

1. Legs entirely black, at most the apices of the coxae yellow; basal antennal joint much elongated (Mass.)..........*longicornis* Loew.
— Legs with a considerable proportion or all of femora and tibiae reddish or yellowish..2
2. Abdomen largely reddish....................................3
— Abdomen black or blackish brown..........................4
3. Abdomen ferruginous, sutures and lateral margins of segments black; legs tawny, tibiae and tarsi brownish and darker than the femora (Martin's Falls and Montreal, Canada)..*fasciatus* Walker.
— Abdomen black, broadly reddish on disc of segments 2 to 5; legs reddish, apical 2 joints of all tarsi blackened (Texas, N. J.)........ ....*abdominalis* Loew.
4. Hind legs almost entirely black, only the extreme bases of femora and tibiae and the larger basal portion of metatarsi whitish yellow (Ill., N. Y., N. J., Pa., N. H.)...........*lugens* Loew, ♀.
— Hind legs with a greater proportion of their surfaces yellowish or whitish...5
5. Legs reddish or tawny, only apices of tarsi blackened...........6
— Legs with some portion of femora or tibiae blackened or browned..7
6. Antennae not longer than head, entirely black; proboscis ("mouth", Walker) yellow (N. Y.)..........*reflectens* Walker.
— Antennae longer than head, tip of first joint and second reddish brown; proboscis black (Wash. State).......*decorus* Williston.
7. Legs reddish, apical third of hind tibiae and apices of tarsi blackened (Mass.; Montreal, Can.; White Mts., N. H.; N. J.; Axton, N. Y.).................... (*persequus* Walker) *rufipes* Loew.
— Legs yellowish testaceous or pale yellow, femora blackened or distinctly browned at apices.................................8
8. Legs yellowish testaceous, all femora broadly sulfurous apically, tips of fore and mid tibiae, hind tibiae except bases, and all tarsi except bases of metatarsi blackened...........*lugens* Loew, ♂.
— Legs pale yellow, apices of all femora, tips of hind tibiae and of all tarsi light brown (Wash., Oregon)...........*gracilis* Williston.

As this key is largely compiled from descriptions it will be necessary to use it with considerable caution. I am not entirely convinced of the specific distinction of several of the species, but without examining the types it is not possible to find characters for the separation other than those given here. Say's species *triangularis* is not, I am convinced, a *Xylophagus.*

Xylophagus lugens Loew

Xylophagus lugens Loew, Berl. Ent. Zeitschr., 1863, p. 6.

Larva (Pl. L, Fig. 5).—Length, 15–20 mm. White, slightly shining, chitinized portions castaneous, glossy. Head long and pointed, with a few surface hairs arranged as in Figure 12; anterior opening very small, mandibles normally slightly exserted; the pair of chitinized rods which protrude into the first thoracic segment usually visible through the semitransparent membrane at back of head. First and second thoracic segments heavily chitinized on dorsum and with narrow pale unchitinized longitudinal lines as shown in Figure 5; spiracle large, situated beyond middle of first segment; armature as shown in Figure 5; last thoracic segment not chitinized; ventral surface of first segment with a brown chitinized patch on each side which is dilated anteriorly and tapers to a point posteriorly; occasionally the median space between these patches anteriorly almost covered with small brown spots; second and third segments without chitinized areas; each of the three segments with a hair on each side near lateral margin slightly beyond middle. Dorsum of abdomen with a transverse band of locomotor spines on anterior margins of segments 1–6 which does not extend to lateral margin; each suture, between both thoracic and abdominal segments, marked by a line of small punctiform brown chitinized areas; laterad, except between segments 7 and 8, this line is duplicated, the two lines enclosing a vertical elongate-oval area which ceases at margin of ventral surface; seventh segment with 4–5 poorly developed spines on each side anteriorly, some distance from median line; eighth segment usually with a few round brown spots on anterior portion about midway from median line to lateral margin, and with a larger chitinized spot on each side of disc near posterior margin; apical segment very heavily chitinized, ending in 2 divergent, slightly upwardly curved processes; spiracles large, round, slightly elevated; dorsum of abdomen, except that of apical segment, without hairs; lateral area of segments 1–7 each with 4 strong hairs arranged in a vertical series on middle of segments, the upper pair more widely separated from the second than the other pairs are from each other; armature of apical segment as in Figure 5; ventral surface different from dorsal in having the locomotor spines present on segments 1–7 and in having a large brown mark surrounding the anal opening.

Pupa (Pl. L, Fig. 1).—Length 10–16 mm. Brownish testaceous, slightly shining, turning almost entirely black just before emergence of adult.

Antennal sheaths distinctly annulated, the anterior basal surface of each with a stout thorn (Pl. L, Fig. 6); entire aspect of head and mouth parts as in figure just mentioned; dorsal surface of head-capsule with 3 small punctiform depressions on ocellar region and on each side a single hair; suture between cephalic and thoracic segments deep, the posterior margin of the former with short longitudinal impressed lines. Thoracic spiracle much elevated, in the form of a short stout tubercle, the apical opening small, somewhat 8-shaped; prothorax with a transverse discal, linear series of small closely placed round depressions; mesothorax with 2 faintly indicated sutures and 2 rather large poorly defined depressions, one behind the other, above wing-base; wings without discal protuberances, their apices rather widely separated, extending distinctly beyond apices of fore tarsi; apices of mid and hind tarsi curved towards median line, the latter extending little beyond apices of wing. Abdominal spiracles similar in form to those of thorax but not so much elevated; first dorsal abdominal segment with 4 weak, widely separated hairs on disc near posterior margin, the median pair much closer to each other than they are to the lateral hairs; lateral areas with 4–6 hairs; segments 2–7 each with a transverse post-median series of closely placed hairs which become progressively slightly stronger from 1 to 7; eighth segment with 4–5 spines on each side of disc in a transverse series; postspiracular area of first segment with 7–8 strong bristles; ventral segments similar in armature to dorsal; apical segment of female as in Figure 2, Plate L.

Larvae of this species were common under bark of a felled elm at White Heath, Ill., March 12, 1916. Several specimens pupated from 3 to 5 days after being brought to the laboratory, and the first imago emerged on March 22, others appearing on the 25th and 26th.

When collecting the larvae I also captured several larvae of *Saperda tridentata*, and others of *Meracantha contracta* (Coleoptera), which I brought in to ascertain whether the xylophagid would eat either of them. One of the Meracantha larvae was eaten, the entire contents being extracted through a hole made in the skin; but the *Saperda* was not attacked. It is very probable that the food of the xylophagid does not consist wholly of the larvae of *Meracantha* as this species was rarely met with in company with the larvae of the fly, and probably *Saperda* is also eaten.

The logs in which I found the larvae were second-year lumber on which the bark was not very loose. When the borings of other insects have thoroughly loosened the bark, conditions are apparently not suitable for the larvae, as none were found in such logs.

The larva and pupa of this species have previously been described by Johnson* and by Felt†, the latter donating an imago and pupal exuvium of *lugens* to the collection of the Laboratory.

Originally described from Illinois, *lugens* has subsequently been recorded from Riverton, N. J.; and from Pennsylvania, New Hampshire, and New York.

Xylophagus abdominalis Loew

Xylophagus abdominalis Loew, Berl. Ent. Zeitschr., 1869, p. 163.

Larva.—Length, 16–21 mm. Differs from larva of *lugens* as follows: the longitudinal pale streak on second thoracic segment simple, not Y-shaped; third thoracic segment with conspicuous, brown, chitinized dorsal patches (Pl. L, Figs. 10, 11); thoracic and abdominal hairs much weaker and paler.

Pupa.—Length, 14 mm. Differs from pupa of *lugens* as follows: antennal sheath without basal thorn (Pl. L, Fig. 7); ventral aspect of head and mouth-parts as in same figure; dorsum of head with about 12 long hairs on each side of disc; thoracic spiracles less elevated; apical segment of abdomen with the bifid process shorter and stouter.

The examples used for the above descriptions were supplied by C. W. Johnson and were found under the bark of a decaying pine-tree at Riverton, N. J.

The species was originally described from Texas, and has not been recorded from any locality except Riverton as far as I am aware.

Family *COENOMYIIDAE*

Only two genera and three species are considered as belonging to this family in North America, but if the catalogues are to be credited one of these, *Coenomyia pallida* Say, has been described by various authors under sixteen or more different specific names. In Aldrich's "Catalogue of North American Diptera" the name accepted for our species is *ferruginea* Scopoli. I have some doubt about the identity of our species with that of Europe, as Beling's description of the larva of *ferruginea* does not fit that before me, and I use Say's name for the species in this paper. The differences are noted on a subsequent page.

---

*Ent. News, Vol. 14, 1903, p. 23.

†Bull. 155, N. Y. State Mus., p. 121. (1912)

I do not know the larvae of *Arthropeas*, which may not conform to the characters here given for the family.

FAMILY CHARACTERS

Larva.—In general appearance similar to Xylophagidae. Head rather large, the exposed portion in the form of a strongly chitinized cone, from the small apical portion of which are protruded the mandibulate parts. Thoracic segments each with a pair of round oval chitinized plates under the skin. Apical abdominal segment obliquely truncated, the lower posterior margin with a pair of projecting processes; posterior spiracles widely separated, situated above middle of apical plate, anterior pair on sides of first thoracic segment.

Pupa.—Head without projecting thorns; antennal sheaths elevated, the annulation indistinct. Abdomen with comparatively weak armature, which becomes stronger apically; postspiracular areas each with 2 bristles; apical segment with a fan-shaped armature of 5–6 bristles on each side; apical protuberances small.

Imago.—Very large, robust species, of a variable brownish or testaceous color. Distinguishable from the Leptidae, in which family it has been placed by some authors, by the elongated and annulated third antennal joint. The males of both genera may be separated from Xylophagidae by the contiguous eyes; both sexes of *Coenomyia*, by the spines on scutellum; and both genera, by the characters given in key to imagines of Brachycera.

HABITS OF LARVAE

The larva of *Coenomyia pallida* is usually found in the ground, those that I have before me being obtained in fields some distance from any timber. They are, however, sometimes found in decaying wood. They are predaceous upon insect larvae. A specimen found in a field near Chicago fed upon white-grubs. The larvae are very sluggish, moving very slowly through the earth, and are almost incapable of making progress upon a smooth surface. I know of no parasites of the larvae.

HABITS OF IMAGINES

Coenomyia pallida is usually found near streams and more particularly among undergrowth or trees, and is rather sluggish. The food consists of fluid matter or nectar of flowers.

Coenomyia pallida Say

Coenomyia pallida Say, Keating's Narrative of an Expedition to the Source of the St. Peter's River, Appendix to Vol. 2, p. 339. (1824)

Larva.—Length, 38–45 mm. White; head and chitinized plate on apical abdominal segment castaneous.

Body cylindrical, slightly tapered anteriorly. Head large, conical, permanently protruded, the movable portions enclosed except at apex; retracted portion consisting of an arcuate dorsal plate and 4 slender chitinized rods (Pl. L, Figs. 3 and 4). Thoracic segments not chitinized externally, but each with a pair of chitinized internal plates which decrease in size from prothorax to metathorax, the anterior pair transversely oval and occupying the greater portion of the ventral surface; ventral hairs of moderate length. Apical abdominal segment with a heavily chitinized plate, the upper margin of which is proximad of the lower, giving the segment the appearance of being obliquely truncated; spiracles round, situated above middle of apical plate; lower margin of plate with 2 short, stout processes (Fig. 9).

Pupa.—Length, 30–35 mm. Dark brown, subopaque.

Head, viewed from in front, as in Figure 8, Plate L, the antennal sheath elevated, with minute thorns, the annulation indistinct. Wings short, extending to apex of first abdominal segment; apices of hind tarsi scarcely extending beyond apices of wings, and closely fused to the latter; thoracic spiracles sessile. Abdominal spiracles of moderate size, their breadth less than their height; basal dorsal abdominal segment with 2 bristles on each side beyond middle; second and following segments up to and including seventh with a complete transverse series of short spines and 6 or more long bristles, the armature increasing in strength up to seventh segment; eighth segment with a group of 2–4 bristles on each side of apex above, a lateral vertical series of 5 longer spines on a raised base, and a pair of stout protuberances, on a single base, on ventral surface at apex (Fig. 12); postspiracular area of each segment with 2 strong bristles; ventral segments with armature similar to that of dorsal but noticeably stronger; apical segment as in Figure 13.

The above descriptions were made from specimens obtained in Illinois, the data being as follows: Du Quoin, August 13, 1908, turned up by plow (L. M. Smith); larval exuvium and pupa, Chicago, August, 1913 (D. K. McMillan); pupal exuvia, Havana, June 15, 1894 and Grafton, August 26, 1905.

The larva obtained by Mr. McMillan fed upon white-grubs in confinement, and as it was taken in a field where these were common

it is very probable that they constituted its food there. The specimen taken by Smith was taken in company with larvae of Asilidae and probably fed also upon white-grubs, which are the principal food of the asilids. The pupal exuvia listed were found protruding from rotten tree-stumps.

In addition to the above we have imagines in our collection here from Algonquin, Chicago, and Fourth Lake—all in Illinois.

The larvae of the European species *ferruginea* Scopoli, is described as having the second thoracic segment with 5 chitinized longitudinal dorsal bands. I can not find these bands on any larvae available to me, and consider it possible that our species may not be the same as the European one.

Family *ACANTHOMERIDAE*

This family is found only in Central and South America, and is considered by some authors as doubtfully separate from Stratiomyiidae.

The larva of one species has been figured by Brauer*, and its general appearance and the structure of the cephalic, thoracic, and apical abdominal segments ally it closely with Coenomyiidae.

Superfamily *Tabanoidea*

I have placed in this superfamily the families Tabanidae and Leptidae.

SUPERFAMILY CHARACTERS

Larva.—Head small, wholly or partly retracted, permanently retracted portion with an arcuate dorsal plate over the longitudinal rods; mandibles strong, hook-like, curved downward; maxillae well developed, wholly or largely membranous, the palpi well developed; antennae distinct, pedunculate. Body cylindrical, with or without pseudopods; lateral abdominal spiracles absent in Tabanidae, small but no lateral spiracles distinguishable in Leptidae; apical spiracles in a vertical fissure in Tabanidae, exposed and separated in Leptidae.

Pupa.—Head without strong cutting armature; antennae with or without distinct annuli. Thoracic respiratory organs sessile. Wings and legs closely fused to each other and to thorax; fore tarsi overlying mid pair, the latter overlying hind pair, the pairs successively longer, hind pair not extending beyond apices of wings. Abdomen

*Denschr. k. Akad. Wissensch. Wien, math.-naturw. Cl., Vol. 47. (1883)

with seven pairs of lateral spiracles; segments armed with transverse series of slender bristles which become progressively stronger from base to apex of abdomen.

Imago.—See descriptions under families, and synopsis in key to imagines of Brachycera.

Family *TABANIDAE*

FAMILY CHARACTERS

Larva.—Head small, retractile, the parts as in Figure 1, Plate LII. Body circular in transverse section, elongate, tapering at both ends, and with encircling locomotor swellings at the segmental sutures in all genera except *Goniops.* In the latter the cephalic and thoracic segments are very much tapered and considerably longer than the abdominal segments; the abdomen is stout and obtusely rounded apically, the locomotor swellings being on the anterior third of each of the well-differentiated segments. The posterior respiratory organs are close together and situated in a vertical cleft.

Pupa.—Head without projecting thorns. Thoracic respiratory organs sessile, connected subcutaneously with a large cavity on each side of median line close to anterior margin of prothorax (Pl. LII, Figs. 2, 3). Wings and legs rather short. Abdominal armature consisting of 1, or 2 closely contiguous, series of bristles on each dorsal segment except first, and a weaker transverse series on ventral segments; apical segment ending in 6 stout processes which are more or less radiate and pointed (Pl. LI, Figs. 4, 5).

Imago.—Distinguished from other Brachycera by the peculiar shape of the third antennal joint, the chitinized portions of proboscis, very robust body, and the wing venation.

HABITS OF LARVAE

Aquatic or semiaquatic, found rarely among decaying leaves or in low and somewhat marshy spots in fields. As far as known, the larvae are predaceous, the food of the species occurring in rivers being mostly tipulid and other larvae which burrow in the soft banks of the rivers or occur in the river bottom or in drift.

Some species are kept in check by the destruction of their eggs by hymenopterous parasites.

HABITS OF IMAGINES

The adults of this family are familiarly known as gadflies, horseflies, clegs, breeze-flies, etc. They rank with the worst of the

biting pests that affect cattle. The species of *Tabanus* attack cattle and other farm animals almost exclusively, but *Chrysops* is a persistent pest to human beings also, especially near rivers, lakes, or large pools. At least one African species of *Chrysops* is responsible for the conveyance of a disease affecting man, which in some respects resembles filiariasis—a disease conveyed by mosquitoes.

Some interesting data upon the egg-laying and other habits of this family are contained in the papers listed at the end of the text on the family.

Key to Genera

LARVAE

1. Body club-shaped, the thoracic segments slender, the abdominal segments robust.............................*Goniops* (p. 356).
— Body tapered anteriorly and posteriorly, not club-shaped........2
2. Apical antennal joint much longer than the preceding joint; dorsum of thoracic segments as strongly striated as those of abdomen.....................................*Chrysops* (p. 357).
— Apical antennal joint not longer than the preceding one; dorsum of thoracic segments either smooth or not as strongly striated as those of abdomen................................*Tabanus* (p. 358).

PUPAE

1. One spine on each side of median line on dorsum of each abdominal segment much stronger than the others in the series....*Goniops*.
— The spines of each series either of an almost uniform strength, or at least no two spines conspicuously stronger than the others..2
2. Antennae projecting beyond lateral margin of head; abdominal spines uniform in length; head with 4 bristles on dorsum (Pl. LII, Fig. 5).......................................*Chrysops*.
— Antennae not projecting beyond lateral margin of head; abdominal spines long and short in each series; head with 2 bristles on dorsum (Pl. LII, Fig. 4)...........................*Tabanus*.

Goniops Aldrich

GENERIC CHARACTERS

Larva.—Mandibles stout, slightly curved, apically truncated; antennae elongate, 3-jointed, basal joint stout, tapering apically, about twice as long as apical 2 combined; apical joint much shorter than preapical; maxillary palpi 2-jointed, the apical joint slender and distinctly shorter than the basal. Thoracic segments very distinctly tapered anteriorly, abdomen stout, roughly oval in outline, the whole

body appearing pyriform or slightly club-shaped; abdominal segments with rather irregularly arranged transverse series of locomotor tubercles; spiracular chamber in the form of a vertical slit.

Pupa.—Head without projecting thorns; antennal sheath short, curved downward. Prothorax about one third as long as mesothorax; wings short, extending to apex of first ventral abdominal segment; apices of hind tarsi slightly surpassing apices of wings. Armature of dorsal abdominal segments consisting of stout thorns in a transverse series, 2 of which, near middle of segments 2 to 7, are much stronger than the others; laterad the series are discontinued some distance from margins; apical segment with 3 strong thorns on each side, between which are several weaker protuberances.

Imago.—The only species of the genus (*chrysocoma* Osten Sacken) may be distinguished from other Tabanidae by the following characters: third antennal joint consisting of 8 segments, the basal one only slightly longer than the next; fourth posterior cell open; eyes of female acutely angled above; hind tibiae with apical spurs.

HABITS OF LARVAE

The eggs are usually deposited on the under side of leaves of various plants, and when the larvae hatch they drop to the ground, living afterwards among the decaying leaves and other vegetable debris. They are very probably predaceous like other Tabanidae.

The egg-masses are parasitized by a proctotrypid species.

HABITS OF IMAGO

The female while ovipositing has the habit—which is very rare among Diptera—of brooding her eggs. The species is very rare, and so far as I know has never been taken in Illinois.

For details of life-history see the papers by McAtee and by Walton listed at the end of the family discussion.

Chrysops Meigen

I have before me a number of larvae belonging to different species of this genus, but only one has been definitely associated with the pupal and imaginal stages.

GENERIC CHARACTERS

Larva (Pl. LI, Fig. 1).—Spindle-shaped, very distinctly tapered towards each extremity. Head small, entirely retractile; antennae

long and rather slender, the apical joint longer than the basal; labrum pointed, armed beneath with some strong short bristles; maxillae stout, their palpi as long as the antennae and stouter, the joints well differentiated; mandibles long and strong, distinctly curved downward and slightly backward. Thorax sometimes with 8 slightly elevated areas that appear somewhat like plates—a broad one on venter, a similar one on dorsum, and 3 narrow ones on each side. Body with close longitudinal striae; pseudopods distinct, arranged in a circular series on anterior margin of each abdominal segment except the apical one; apical segment with the spiracular portion retractile, the spiracles in a vertical cleft.

Pupa.—Similar in general appearance to the pupa of *Tabanus* (Pl. LI, Fig. 6), the principal differences between the genera as stated in the key.

TABANUS Linné

In point of numbers this genus is the largest of the family, and it also contains the largest species, some of them exceeding an inch in length.

GENERIC CHARACTERS

Larva.—The larvae of *Tabanus* closely resemble those of *Chrysops* in general structure, being elongate, circular in cross-section tapering at both extremities, and armed, at least on the abdominal segments, with more or less well-defined pseudopod-like tubercles—2 on dorsum and 4 on venter—which usually form an almost complete circle on the segments anteriorly. Head as in Figure 1, Plate LII. The structure of the antennae separates the two genera.

Pupa (Pl. LI, Fig. 6).—The antennae are shorter in *Tabanus* than in *Chrysops*, the thoracic spiracles are rather different in structure, being more nearly vertical, and the abdominal armature differs as indicated in the preceding key to genera.

Imago.—The hind tibiae differ from those of *Chrysops* in having apical spurs. From other Tabanidae possessing hind tibial spurs the species may be distinguished by the 5-segmented third antennal joint, with its distinct dorsal basal angle, and the absence of a cilia of hairs on the hind tibia.

HABITS OF LARVAE

See under family.

HABITS OF IMAGINES

The species of this genus are very serious pests of cattle, and cause considerable loss to cattlemen in well-watered areas where they

occur commonly. Some success in destroying the flies has been attained by spreading a film of kerosene on the surface of pools where the insects occur. The flies have a peculiar habit of dipping down to the surface of the water, assumably for the purpose of drinking, and when the oil is present large numbers are destroyed. Various skin lotions, or washes, consisting of lard and sulphur or of carbolic acid in varying strength, have been tried as repellents, but usually with very little success. Even hogs that are regularly washed with various crude-oil preparations to destroy lice are attacked freely by such species as *atratus*.

Some of the larger asilids, or robber-flies, prey upon the adults and succeed in killing even the largest of them.

Keys to Species

LARVAE

1. Body without markings either of color or hairs................2
— Body either with a series of distinct brown spots or with brown marks 3
2. Body very closely and finely striated, entirely white. *Tabanus* sp. 1.
— Body coarsely striate, abdominal segments each with an indistinct pale annulus on anterior margin......................*costalis*.
3. Abdominal segments with very faint anterior annuli.....*costalis*.
— Abdominal segments either with very well-defined anterior annuli or each segment with a brown spot on each side on extremity of dorsal transverse swelling...............................4
4. Brown markings consisting of a small spot on the outer extremity of each dorsal abdominal transverse swelling......*Tabanus* sp. 2.
— Brown markings in the form of well-defined annuli............5
5. Lateral raised striated areas of prothorax each about as long as the dorsal one ....*lineola*.
— Lateral raised striated areas of prothorax each about half as long as dorsal one 6
6. Brown stripe between dorsal striated area and upper lateral one dilated posteriorly, causing the former to be parallel-sided on its posterior half (Pl. LI, Fig. 3).......................*atratus*.
— Brown stripe between dorsal striated area and upper lateral one tapered, or at least not dilated, posteriorly, the sides of the dorsal area divergent throughout their entire length (Pl. LI, Fig. 2)..7
7. Lateral striae of prothorax very fine, opaque, those of metathorax much coarser, shining.........................*Tabanus* sp. 3.
— Lateral striae of prothorax but little finer than those of mesothorax ....*stygius* and *nigrescens*.

PUPAE

1. Dorsal abdominal segments, except first, armed with an irregular transverse series, or 2 such series, of very stout thorns, their bases very much dilated, slightly caudad of which series there are sometimes a few widely separated, much longer spines............2
— Dorsal abdominal segments, 4 to 6 at least, with 1 or 2 transverse series of short irregular spines the bases of which are not much dilated, and slightly caudad of these is a transverse series of closely placed, very long, slender bristles....................4
2. Seventh dorsal abdominal segment with 10—12 moderately long thorns in a continuous transverse series, slightly cephalad of which is a transverse series of very short stout thorns longitudinally in line with the spaces between the thorns of the posterior series.... ....*carolinensis* Macquart.
— Seventh dorsal abdominal segment with the posterior transverse series consisting of 2 long, widely separated spines on middle portion, and several, closely placed, on each lateral extremity which are but little caudad of the much shorter thorns of the anterior series...3
3. The portion of head-capsule between bases of antennae distinctly elevated, flattened, strongly rugose, the lower extremity of the elevation strongly carinate and with a central incision; abdominal armature very strong, having much the appearance dorsally of a single irregular transverse series on each segment............. ....*lasiophthalmus* Macquart.
— The portion of head-capsule between bases of antennae slightly elevated, rounded, faintly rugose, and not carinate or divided below; abdominal armature moderately strong, distinctly biserial laterally................................*epistates* Osten Sacken.
4. Small species, 20 mm. or less in length; abdominal spiracles with C-shaped rima 5
— Larger species, at least 25 mm. in length; abdominal spiracles with very much elongated vertical rima, the upper and lower extremities slightly curved forward...............................6
5. Bristles on eighth ventral abdominal segment fused basally, giving them the appearance of an elevated ridge with a serrate edge.... ....*lineola* Fabricius.
— Bristles on eighth ventral abdominal segment not fused basally.... ....*costalis* Wiedemann.
6. The long spines on dorsal abdominal segments with a ring beyond middle and their apices black; short spines on median portion of each anterior transverse dorsal series stout and almost uniform in length ....*atratus* Fabricius.
— The long spines on dorsal abdominal segments either black-tipped or all pale, without a black preapical ring; short spines in anterior dorsal series slender and very uneven...................7

7. A small but distinct tubercle just in front of base of middle leg in addition to and some distance above the one bearing the paired hairs*........................*nigrescens* Palisot de Beauvais.
— No tubercle present as above........................*stygius* Say.

In order to keep this paper within reasonable limits I have not drawn up descriptions of the larvae and pupae of this genus, reserving that for a future article in which I hope to cover the family.

Most of the species have already been described by C. A. Hart in his paper "On the Entomology of the Illinois River and Adjacent Waters†. My Species 1 is the only larva not included in that paper. It differs from the other larvae before me in being entirely white and without lines or patches of pubescence, as well as in being more robust, and less tapered at the extremities. In general appearance it very closely resembles an asilid larva, the resemblance being accentuated by the small size of the locomotor organs; and it stood as "Asilidae" in our collection. The specimen was obtained at Pulaski, Ill., June 1, 1910, in a pit-cage used in rearing white-grubs. This is a surprising occurrence as most of the species are confined to damp ground or to aquatic surroundings.

The species designated as Species 2 and Species 3 in the key to larvae are Hart's species *a* and *b*.

Principal Papers dealing with the Biology of North American Tabanidae‡

Hine, J. S.

'03. Tabanidae of Ohio. Special Papers, Ohio State Acad. Sci., No. 5.

'06. Habits and life histories of some flies of the family Tabanidae, Tech. Ser., No. 12, Pt. 2, Bur. Ent., U. S. Dept. Agr.

'06a. A preliminary report on the horse-flies of Louisiana, with a discussion of remedies and natural enemies. Circ. 6, State Crop Pest Commission of La.

'07. Second paper upon the horse-flies of Louisiana. Bull. 93, Agr. Exper. Station La., State Univ.

McAtee, W. L.

'11. Facts in the life-history of *Goniops chrysocoma*. Proc. Ent. Soc. Washington, 13: 21.

Walton, W. R.

'08. Notes on the egg and larva of *Goniops chrysocoma* (O. S.). Ent. News, 19: 464.

---

*I do not know whether this character will hold good in a series as my material contains only one specimen of *nigrescens* (in very poor condition) and but 2 of *stygius*.

†Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI. (1895)

‡See also C. A. Hart's Art. VI, Vol. 4, Bull. Ill. State Lab. Nat. Hist. (1895)

Family *LEPTIDAE*

In the present paper I have limited this family to include only the genera placed in the subfamily Leptinae in Williston's Manual of North American Diptera. This grouping is not a new one, having been used by Brauer and several subsequent writers, and from a phylogenetic point of view it has much to recommend its general adoption.

FAMILY CHARACTERS

Larva.—Head with a rather small protruded portion; maxillae not so prominent or so heavily chitinized as in Asilidae, closely resembling those of Tabanidae; maxillary palpi well developed; mandibles vertical, parallel, curved, and very long; retracted portion of head with a large arcuate upper covering which is not very heavily chitinized, and 4 elongate rods. Body in terrestrial forms circular in cross-section, distinctly tapered anteriorly, without pseudopods; lateral spiracles on metathorax and abdomen very small; in aquatic forms body slightly flattened and with paired abdominal pseudopods and dorsal and lateral filaments; anterior spiracles small; posterior pair large, located, in terrestrial forms, under a single flap-like process or at the base of an upper pair of pointed processes; in aquatic forms the spiracles are not distinguishable, and there are two rounded, protrusive blood-gills on apical segment below the bases of the long terminal appendages.

Pupa.—Head without projecting thorns; antennae short, swollen at base, slender apically, directed downward and slightly outward. Thoracic respiratory organs sessile (terrestrial forms); wings extending to second or third abdominal segment; hind legs extending to apex of wings or slightly beyond that point. Abdomen with a transverse series of bristles on each segment, the series becoming stronger towards apex of abdomen.

Imago.—Robust species with short antennae and stout legs. For characters to distinguish the family from other Brachycera see key to imagines of this division.

HABITS OF LARVAE

Only one genus known to me is aquatic—*Atherix*. The terrestrial forms are found in rotten wood or in the ground in woods, generally under thick covering of leaves or under decaying logs or tree-stumps. They are predaceous, feeding upon larvae of other insects, and probably also upon worms. The species which I have reared were very

sluggish in the larval stage, but Beling mentions that one species in Europe is very active.

The larvae are frequently attacked and killed by internal nematode parasites.

HABITS OF IMAGINES

Some species are predaceous, feeding upon soft-bodied insects, but the greatest number are found upon flowers. Tree-trunks or fence-posts are favorite resting-places of the species of *Leptis,* where they invariably assume a position with the head downward. Some species of *Chrysopila* usually frequent the densest portions of woodlands, and others are found commonly only on marshy ground.

Several species of *Symphoromyia* are known to attack man and cattle in this country, inflicting very painful bites.

The females of the genus *Atherix* have a peculiar egg-laying habit. The eggs are deposited upon branches or twigs of willow or other trees overhanging streams. After oviposition the female does not fly away, but dies and remains attached to her egg-mass. A second female adds to the already deposited mass both her eggs and her body, and gradually others do likewise, until the combined mass of eggs and flies assumes considerable proportions, often containing several thousand dead flies. The larvae which hatch, drop from the mass into the stream below, where they pass the immature stages. The Indians in Oregon at one time collected the masses of eggs and flies and used them as food. An interesting account of this aboriginal utilization of nature's resources is given by Prof. J. M. Aldrich.*

Key to Genera†

LARVAE

1. Apical abdominal segment ending in 2 long stalk-like processes, which are fringed with long soft hairs; paired pseudopods present on abdominal segments; aquatic species................*Atherix.*

— Apical abdominal segment ending in 2 fleshy lips or in 4 tapering points, the spiracles situated at the base of the upper processes; paired pseudopods absent; terrestrial species.................2

2. Apical abdominal segment ending in 2 fleshy lips, an upper and a lower, the inner surfaces of which are brown....*Symphoromyia.*

— Apical abdominal segments ending in 4 pointed processes, the inner surfaces of which are pale.................................3

---

*Ent. News, Vol. 23, 1912, pp. 159–163.

†I have pupae of *Chrysopila* only, and can not give a key for the separation of the genera in this stage. For a key to the imagines use should be made of that to Leptinae in Williston's "Manual".

3. A small projection on outer under side of base of upper protuberance . . . . *Chrysopila.*
— No small projection on outer under side of base of upper protuberance . . . . *Leptis.*

ATHERIX Meigen

GENERIC CHARACTERS

Larva (Pl. LII, Fig. 10).—Head small, entirely retractile, internally pyriform. Abdomen with lateral appendages and well-developed paired pseudopods which are armed with curved apical spines, as shown in Figure 10, Plate LII; apical segment ending in 2 long protuberances which are fringed with long hairs; 2 rounded blood-gills below base of apical protuberances.

Pupa.—Unknown to me.

Imago.—The species differ from those of other Leptidae in possessing the following combination of characters: third antennal joint reniform; basal antennal joint not thickened; arista dorsal; third tibiae with 2 spurs; front tibiae without apical spurs; anal cell closed; discal cell present.

HABITS OF LARVAE

The larvae are aquatic, living in flowing streams.

I have not seen any larvae of this genus from Illinois, the material before me being all from streams in Yellowstone National Park (S. A. Forbes) and from mountain streams in Montana (C. C. Adams).

HABITS OF IMAGINES

See under family.

SYMPHOROMYIA Frauenfeld

I have not seen larvae of this genus, and the characters used in the key are from Beling's published description of a European species.

CHRYSOPILA Macquart

GENERIC CHARACTERS

Larva (Pl. LII, Fig. 6).—White. Tapered anteriorly, stout posteriorly, the apical segment ending in 4 stout processes, between the lateral pairs of which is a smaller process (Pl. LII, Fig. 11); head as in Figure 8. Anterior spiracles small, lateral metathoracic and

abdominal pairs minute, posterior pair large, circular, situated on ventral surface of the upper pair of apical processes. Body bare except for the usual 6 thoracic hairs.

Pupa (Pl. LII, Fig. 7).—Head without spines; antennae stout basally, slender apically, directed downward and slightly outward; thoracic respiratory organs sessile. Wings and legs short, extending to apex of first segment. Abdomen with spinose armature which becomes stronger apically; apical segment with stout processes which are not thorn-like.

Imago.—Distinguished from other genera by the following characters: third antennal joint conical or subconical, with a slender terminal arista; discal cell of wings present; 5 posterior cells; anal cell closed; hind tibia with 1 spur.

HABITS OF LARVAE AND IMAGINES

See under family.

KEYS TO SPECIES

LARVAE

1. Large species, 15 mm., or more, in length; neither the upper nor lower anal protuberances with well-defined lateral process (Pl. LII, Fig. 11) .... *ornata.*
— Smaller species, about 10 mm. in length; either the upper or lower anal protuberances, or both, with well-defined lateral process....2
2. Only the lower anal protuberances with well-defined lateral process (Pl. LII, Fig. 12) .... *quadrata.*
— Both upper and lower protuberances with well-defined lateral processes (Pl. LII, Fig. 9) .... sp. ?

PUPAE

1. Large species, 16 mm., or more, in length; apical abdominal segment with 8 thorns (Pl. LII, Fig. 13) .... *ornata.*
— Smaller species, about 10 mm. in length; apical abdominal segment with 8 strong thorns and several smaller ones (Pl. LII, Fig. 14) .... *quadrata.*

CHRYSOPILA ORNATA Say

Leptis ornata Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 34.

Larva (Pl. LII, Fig. 6).—Length, 15–20 mm. White. Anterior spiracles brown, posterior pair black.

Head as in Figure 8, retractile and rather small, the permanently retracted portion subpyriform and consisting of a dorsal, rather poorly chitinized, arcuate plate, and 4 strong, though slender, rods. Body circular in cross-section; lateral areas limited by an incised line above and below; thoracic segments tapered anteriorly, anterior margins of all segments with fusiform areas ventrally and a band of locomotor setulae round the entire margin; apical segment (Fig. 11) with 4 large flattened, pointed protuberances, which have on their lateral margins a poorly developed process and between the upper and lower pairs a distinct tooth-like projection; each of the large protuberances with a long hair on inner surface near apex; spiracles large, round, situated near base on under side of upper pair of processes.

Pupa (Pl. LII, Fig. 7).—Length, 14–17 mm. Brown. Head without thorns; a pair of small warts above bases of antennae, the latter slightly elevated; cephalic capsule with a distinct wart, bearing a strong hair, just above each eye. Thoracic spiracles in the form of elevated, rough, wart-like protuberances, the opening linear; an area on anterior margin close to median line elevated in the form of an irregularly rugose wart; prothorax separated from mesothorax by an incised line which is not very distinct. Wings short, extending to apex of first ventral abdominal segment; legs short, apices of fore tarsi not reaching apices of wings, those of mid tarsi reaching them, and those of hind pair extending beyond them but curved inward so that they do not surpass the basal third of second abdominal segment. Abdomen more than twice as long as thorax, very slightly tapered apically; lateral areas defined by means of a line of punctures above and below; spiracles elevated, appearing like sharp vertical ridges; armature consisting of a girdle of stout, flattened spines near posterior margin of each segment from 2 to 7, the strength of the spines increasing slightly posteriorly; apical segment with 8 spines, 3 on each side, beginning at middle of side and extending upward, and 2 on ventral margin close together (Fig. 13).

The foregoing descriptions were made from specimens obtained at Cottonwood Grove, near Urbana, Ill., in April, 1916. One example obtained April 23, pupated May 9, and emerged May 25.

The specimens were found in the earth under leaves, and more commonly in slight depressions or under rotten wood where there was considerable dampness and a number of other insect larvae and worms.

A white nematode was found as an internal parasite. Hine has recorded the finding of the larva and pupa of this species in Ohio.

The range of the species is from the Mississippi eastward; it is common in Illinois.

Chrysopila quadrata Say

Leptis quadrata Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 35.

Larva.—Similar in general appearance to the larva of *ornata*, but differing noticeably in size, its length being only about 10 mm. The other principal distinction lies in the structure of the apical abdominal segment, which is as shown in Figure 12, Plate LII.

Pupa.—Very similar in structure to *ornata*. The abdominal spiracles are much smaller, however, and the apical segment has in addition to the 8 long spines borne by *ornata* several smaller ones, as shown in Figure 14.

The foregoing descriptions were made from specimens obtained at Cottonwood Grove, near Urbana, Ill., April 23, 1916. The larvae occurred along with those of *ornata* under a decaying log. The imagines emerged May 30 and 31.

Chrysopila sp.

I have before me the larva of a third species of this genus. It is 12 mm. in length, and differs from *quadrata* in having the apex of the abdomen with well-defined lateral processes on both the upper and lower protuberances (Fig. 9).

This larva was found under fallen leaves at Charleston, Ill., August 22, 1910. It is almost certainly not full-grown, for taken so late in summer it would doubtless have remained in the larval stage till May of the next year.

Chrysopila foeda Loew

Chrysopila foeda Loew, Berl. Ent. Zeitschr., 1861, p. 317.

The larva and pupa of this species were described by Coquillett in 1883*. The descriptions present no characters that enable me to distinguish the larva and pupa from those which I have before me.

Leptis Fabricius

I have not seen the larva of any species of this genus.

I consider the species figured by Banks as *Anthomyia* sp., Fig. 117 in his paper on dipterous larvae†, as probably belonging to *Leptis*—certainly not to *Anthomyia*.

---

*Can. Ent., Vol. 15, p. 112.

†The Structure of certain Dipterous Larvae, with particular Reference to those in Human Foods. Tech. Ser., No. 22, Bur. Ent., U. S. Dept. Agr., Pl. VI. (1912)

Superfamily *Cyrtoidea*

I have provisionally placed in this superfamily two families, Cyrtidae and Nemestrinidae. I have seen the young larva and the pupa of Cyrtidae, but the other family is quite unknown to me. I have some doubts as to the propriety of linking these families together but can not suggest a better affiliation for Nemestrinidae, though the imagines are more dissimilar than is the rule in most superfamilies in Brachycera.

The larva of one species of Nemestrinidae has been described by Brauer. The species is recorded as being an internal parasite of coleopterous larvae.

Family *CYRTIDAE*

Larva.—First-stage larva very active, armed on body with numerous spinose plates and single spines and with 2 long apical bristles, the latter serving as a means of propulsion in making the leaps which the larvae take before entering their hosts. On finding a location in the host the appearance of the larva changes radically, and it becomes maggot-like and very sluggish. The head is very small and almost entirely retracted. The prothoracic spiracles are minute, the anal pair much larger, slightly elevated, distinctly separated, and situated on the apical segment. The segmentation is rather indistinct, but the thoracic segments are clearly differentiated from the abdomen, being much more slender. The locomotor organs consist of a pair of slight elevations on segments 5–11 which are armed with minute spinules.

Pupa (Pl. LIII, Fig. 1).—Distinguished from every other family by the very large thorax, which exceeds the abdomen in length, by the short, stout abdomen, with its apex slightly recurved ventrally, by the 4 or 5 pairs of lateral abdominal spiracles, and by the entire absence of bristles or thorns on all parts of the body.

Imago.—Distinguished by the very small head, globose thorax, and very short, stout abdomen.

HABITS OF LARVAE

The larvae are internal parasites of spiders, passing the winter within the body of their hosts.

HABITS OF IMAGINES

The imagines are commonly rare, but occasionally they may be taken in considerable numbers flying round or settling upon dead

twigs of trees on which they lay their eggs. It is possible that the flies select these outstanding dead twigs because they are the haunts of many of the spiders that serve as the hosts of the larvae.

Papers on North American Cyrtidae

Johnson, C. W.
'15. Notes on the species of the genus *Acrocera*. Psyche, 22: 198.

King, J. L.
'16. Observations on the life-history of *Pterodontia flavipes* Gray. Ann. Ent. Soc. Amer., 9: 309–321. (Contains the principal facts regarding the life history of the family, and a complete bibliography.)

Malloch, J. R.
'16. Some additional records of Chironomidae for Illinois and notes on other Illinois Diptera. Bull. Ill. State Lab. Nat. Hist., Art. IV, 11: 341–342.

Melander, A. L.
'02. Notes on the Acroceridae. Ent. News, 13: 179.

Superfamily *Asiloidea*

I have grouped together in this superfamily the families Mydaidae, Apioceridae, Asilidae, and Bombyliidae. This arrangement is in accord with that of Brauer but is radically different from that of Osten Sacken and Verrall, both of whom place the families specified in different superfamilies.

SUPERFAMILY CHARACTERS

Larva.—Head in Mydaidae and Asilidae with the exposed portion heavily chitinized, the maxillae broad, flattened dorso-ventrally, usually subtriangular when seen from above, the palpi normally distinct; labrum variable in length, generally pointed; mandibles knife-shaped, situated on each side of labrum and moving vertically between it and the maxillae; antennae small, generally difficult to distinguish. Body cylindrical or subcylindrical, segmentation distinct, seldom with secondary divisions, but if these are present there are also distinct locomotor protuberances on the abdominal segments; thoracic segments each with 2 long hairs on each side of venter. Apical segment somewhat variable, rounded in most genera but occasionally with a sharp upper posterior edge or, rarely, with 2 or 3 slightly chitinized projections on upper posterior margin, never with finger-like fleshy processes; prothoracic and anal spiracles distinct, the latter situated

on the penultimate segment, which in some Asilidae is very short and appreciably sunken. In Mydaidae and Asilidae there are very small functionless (?) spiracles on the metathoracic and basal 7 abdominal segments. In Bombyliidae the head is much less heavily chitinized than in the other families, but the presence of the anal spiracles on the penultimate segment indicates the relationship with the others. The abdomen has no distinct spiracles except the apical pair, and the apical segment has no hairs.

Pupa.—The armature of the head is usually sufficiently distinct from that of any other brachycerous family to distinguish the pupa, as no other possesses strong thorns on the antennae such as are shown in the figures for three of the families included in Asiloidea (Pl. LIII, Fig. 3; Pl. LIV, Fig. 7; Pl. LVI, Fig. 3). The only genus of this superfamily known to me that does not have these thorns is *Leptogaster,* but here the characteristic abdominal armature of the Asiloidea—consisting of strong curved thorns alternating with much weaker bristles in single transverse series—readily separates the pupa from those of Empidoidea. The pupae of Therevoidea have only one thorn on the base of each antenna and in some other respects differ from those of Asiloidea.

HABITS OF LARVAE

The larvae are either predaceous or parasitic, and may be considered beneficial—with the exception of those that are parasitic upon parasites of injurious insects, such as *Tiphia,* the parasitic enemy of white-grubs. The habits of the various genera are dealt with under the different family headings.

HABITS OF IMAGINES

The imagines of all Asilidae known to me are predaceous, feeding upon other insects. Some authors have recorded Mydaidae as feeding upon insects, but I have not seen the species known to me doing so. The imagines of Bombyliidae are, so far as I know, flower-frequenters, feeding upon nectar.

Family *MYDAIDAE*

The insects constituting this family have been considered as entitled to superfamily rank by Osten Sacken. Verrall has conceded their claim to separation from the other superfamilies in Brachycera, but links the Scenopinidae with them under the superfamily name Dermatina. Brauer, in one of his earlier papers, attempted to associate

Mydaidae and Scenopinidae but separated them widely in his later, more comprehensive works, associating the scenopinids with the family Therevidae, and basing his argument for so doing upon the structure of the larva. In the present paper I have considered the family as belonging to the superfamily Asiloidea.

FAMILY CHARACTERS

Larva (Pl. LIII, Fig. 4).—White, usually very large and robust, with clearly differentiated segments; head rather large, under a low power appearing like a solid black cone; maxillae chitinized, pointed apically, not abruptly differentiated posteriorly, their inner surfaces clothed with stout, branched spines (Fig. 2); mandibles long, curved, slender, their apices extending to those of maxillae and beyond apex of the slender labrum; surface of head with several long hairs. Thoracic segments slightly tapering anteriorly, only a slight rounded shoulder to anterior margin of first segment; prothoracic spiracles rather small; metathorax with a pair of small spiracles; the usual 6 thoracic hairs, as in Asilidae, present. Abdominal and posterior thoracic segments slightly flattened dorso-ventrally and with a distinct lateral bead-like extension, the segments not as long as their dorsal width, those of abdomen with a rather abrupt transverse depression along their anterior dorsal margin except in the case of the apical 2; abdomen with small lateral spiracles on segments 1–7; middle ventral segments of abdomen each with a transverse series of 4 rather irregular pseudopod-like elevations near anterior margin; penultimate segment with 2 large round spiracles close to anterior margin, and a sharply defined transverse depression on its posterior margin; apical segment with a rather sharp ridge along the posterior margin, and armed with several hairs.

Pupa (Pl. LIII, Fig. 3).—Upper pair of cephalic thorns directed upward and slightly outward; lateral cephalic thorns 2 in number. Apices of wings extending beyond apices of mid tarsi; abdominal segments each with a girdle of stout thorns; apical segment with 2 stout, tapering terminal thorns.

Imago.—The elongate shape of the insects, together with their strong posterior legs and peculiar forwardly curved apical wing-venation, makes it a simple matter to identify the species in the field. The flies are usually deep black with contrasting reddish or yellowish color on wings, legs, or abdomen.

Mydas clavatus is the largest North American dipteron, and all the Mydaidae recorded from this country are of considerable size.

HABITS OF LARVAE

The larvae are predaceous, and are usually found in decaying wood, where their food consists principally of the larvae of wood-boring Coleoptera.

HABITS OF IMAGINES

The imagines of *Mydas clavatus* are found upon flowers of milk-weed principally, and although stated to be predaceous I have never found them with any prey. They fly most readily on bright, sunny days, and select the most exposed situations.

MYDAS CLAVATUS Drury

Musca clavatus Drury, Illustrations of Natural History, Vol. 1, p. 103. (1770)

Larva (Pl. LIII, Fig. 4).—Length, 45–50 mm. White, head and spiracles black.

Head as in Figure 5; maxilla as in Figure 2. Apical segment slightly carinated on upper posterior margin.

Pupa (Pl. LIII, Fig. 3).—Length, 34–38 mm. Reddish brown, subopaque.

A strong upwardly directed pair of slightly divergent thorns on upper surface of head; antennal sheath with 2 strong downwardly and slightly outwardly directed thorns; a pair of short thorns, on a common base, at base of middle leg on margin of thorax and another pair above base of wings; apices of middle legs not extending to apices of wings. Armature of abdomen consisting of strong, flattened thorns, those of first segment directed forward, the others backward and slightly upward; apical segment ending in a pair of conical processes.

The above descriptions and the illustrations accompanying were made from three larvae and two pupae in our Laboratory collection. The larvae were obtained in Illinois, two being without data, the other having been taken at Pulaski, June 9, 1907. The pupal exuvia bear the following data: White Heath, Ill., May 26, 1910, larva found in rotten stump; and Quiver Lake, Havana, June 19, 1894.

The drawing of the larval head is incomplete anteriorly, the specimen being in bad shape, and showing neither maxillary palpi nor antennae. The general appearance of the larva is, however, sufficient to enable one to recognize it.

Walsh has described a species under the name *fulvipes*. The larval and pupal descriptions are very general and agree with the above as

far as they go. A comparison of specimens would be necessary to discover specific distinctions.

Family *APIOCERIDAE*

The species of this family with two exceptions are unknown to me. They are, as far as known, confined to the south-western states and Mexico. There is a diversity of opinion regarding their super-family location, and I have placed the family in Asiloidea with considerable hesitation, as the flies appear to resemble the family Nemestrinidae to some extent. A knowledge of the larval and pupal characters would undoubtedly throw much light upon their relationships.

Family *ASILIDAE*

FAMILY CHARACTERS

Larva.—The structure of the segment which bears the posterior spiracles is generally the most readily appreciable character for the recognition of the larvae of this family, as it is sharply differentiated from the adjoining segments in most of the known forms, being occasionally very short and appearing in the form of a slightly depressed strip. *Leptogaster flavipes*, however, has this segment at least as long as the last one and not appreciably depressed. There is some variation in the form of the head in the different genera, but as far as I have seen they all present much the same general structure, the maxillae being particularly well developed, flattened dorso-ventrally and more or less triangular in shape. The thoracic segments are each armed with a single long hair on the middle of the latero-ventral line, and the anterior spiracle is well developed. The abdominal segments are well differentiated in those genera that I have examined, and except the apical one bare. The lateral spiracles on metathorax and abdomen are small but distinct. *Laphria*, as figured by Brauer, presents an exception to the general rule obtaining throughout the known members of the family in having the first 6 abdominal segments subdivided and the anterior portion of each with 6 wart-like protuberances—2 on dorsum and 4 on venter.

Pupa.—With the exception of *Leptogaster flavipes* all of the pupae known to me have the antennal sheath with 3 to 5 stout thorns (referred to in this paper as the "lateral cephalic thorns"), and the dorsal abdominal armature consisting of stout thorns in transverse series, the sizes alternating large and small on the central portion of each series. In one of my published papers on the pupae of these groups I

used this character to distinguish the pupae of Asilidae from those of Bombyliidae, the latter having alternating stout thorns and long slender hairs in the transverse armature of the abdominal segments, but owing to the occurrence in *Leptogaster flavipes* of an armature that differs almost as decidedly from that of other Asilidae as it does from Bombyliidae I have had to re-draft the statement of distinctions. In all the Bombyliidae known to me there are 2 closely approximated thorns on the lower central portion of the face, which are in some species fused almost to their apices; these thorns I have not found present in any species of Asilidae, not excepting *Leptogaster*. It is not improbable that further revision will be necessary as the pupae of more genera are obtained.

Imago.—The synoptic key to imagines of Brachycera presents a summary of the characters for the recognition of the imagines. The generic key in Williston's "Manual of North American Diptera" is sufficient for the identification of the genera.

HABITS OF LARVAE

All of the larvae of this family that I have found, are predaceous, feeding upon other insect larvae, either in decaying wood or in the ground, and may thus be considered generally as beneficial. Several species, such as *Promachus fitchii, P. vertebratus, Deromyia discolor, D. winthemi, Proctacanthus milberti, Erax maculatus,* and *E. aestuans* are instrumental in reducing the numbers of white-grubs in cultivated ground. *Asilus notatus* and *Leptogaster flavipes* I have found only in or near woods, and especially in or under decaying wood, and it is very probable that they confine themselves to attacks upon species that are found in such situations—Tenebrionidae and Cerambycidae particularly.

The transformation to the pupal stage is preceded by four or five days in a semi-quiescent condition, during which the gradual development of the imaginal parts may be clearly seen through the transparent skin of the larva. The pupa is capable of making its way through the ground either backward or forward, and prior to the exclusion of the imago makes its way to the surface, where the exuvium is left projecting half-way out of the ground after the imago has flown away.

HABITS OF IMAGINES

Like the larvae, the imagines are predaceous as a general rule, but very often some species may be taken on flowers, where they undoubtedly partake of the nectar. Some of the genera I have taken only on

flowers and never with prey, but my observations do not cover a long enough period to permit a definite statement as to the habits of the species of such genera as *Holcocephala*. The larger species, and particularly those that are of economic importance in the larval stages, are predaceous almost exclusively, attacking bees, wasps, and even other asilids, which they kill by inserting their proboscis through the thin membrane of the anterior portion of the thorax just below the dorsum, and through this opening extracting the body fluids.

I have found no parasitic enemies of either larvae or pupae, but the various stages of the species are preyed upon by insectivorous birds and mammals, and even by members of their own family.

Keys to Genera and Species

LARVAE

1. Maxillae with an angular incision on outer side about middle; abdominal segments 1–6 each with circle of 6 pseudopods on the anterior half.......................... { *Dasyllis*..... (p. 380). *Ceraturgus*? (p. 379). *Laphria*. }

— Maxillae without an incision on outer side, posterior lateral extremity more or less distinctly angulated..........................2

2. Very small species, averaging less than 10 mm. in length; mandibles aborted; penultimate abdominal segment as long as ultimate.... ....*Leptogaster flavipes* (p. 377).

— Larger species, at least 15 mm. in length; mandibles extending at least midway to apices of maxillae..........................3

3. Maxillary palpi at least 3 times as long as their diameter (Pl. LIV, Fig. 10)..........................*Asilus notatus* (p. 385).

— Maxillary palpi at most twice as long as their diameter..........4

4. Antennae indistinguishable; short, robust species with distinct locomotor elevations on venter; maxillae without a distinct incision at base of palpi......................*Deromyia discolor* (p. 384).

— Antennae distinct; if the species is short and robust the maxillae have a distinct incision at base of palpi (Pl. LIV, Fig. 5)......5

5. Posterior discal cephalic hair much nearer to antenna than to posterior margin of head; body robust, slightly flattened dorso-ventrally, the segments shorter than broad...................... ....*Promachus fitchii* (p. 383).

— Posterior discal cephalic hair nearly midway between antenna and posterior margin of head; body slender, rounded, segments longer than broad..........................*Promachus vertebratus*.

PUPAE

1. Head without sharp forward-directed thorns, at most with slight carinated elevations; abdomen with strong curved thorns and intervening slender hairs...........*Leptogaster flavipes* (p. 377).

— Head with long, sharp, forward-directed thorns; abdomen with long and short straight thorns alternating....................2

2. Thoracic spiracle slightly elevated, rugose, without well-defined reniform area (*Promachus*)..............................3

— Thoracic spiracle with distinctly elevated, well-defined, reniform area...5

3. Lateral cephalic process consisting of 3 thorns, the upper one bifid or sometimes duplicated so that the process appears quadrispinose; the last 5–6 thorns on lateral extremities of transverse armature of abdominal segments 2–7 very slender, their bases swollen but not fused; eighth ventral abdominal segment of male with 4 thorns......................*Promachus fitchii* (p. 383).

— Lateral cephalic process consisting of 3 simple thorns............4

4. Large species, averaging over 25 mm. in length; last 4–5 thorns on lateral extremities of transverse armature of dorsal abdominal segments 2–7 stout, flattened and rather wedge-shaped, their bases fused; intermediate short thorns present between the long ones on tranverse series of seventh dorsal abdominal segment.... ....*Promachus vertebratus.*

— Smaller species, about 20 mm. in length; last 4–6 thorns on lateral extremities of transverse armature of dorsal abdominal segments 2–7 slender but not fused; intermediate short thorns absent from transverse armature of seventh abdominal segment........... ....*Promachus* sp.

5. Apices of fore tarsi extending very distinctly caudad of apices of wings (*Deromyia*)..............................6

— Apices of fore tarsi not extending to apices of wings............7

6. Ventral abdominal segments 3–7 each with an uninterrupted transverse median series of closely placed bristles.*Deromyia winthemi.*

— Ventral abdominal segments 3–7 each with 3 short transverse series of rather stout spines—one on each side and one in middle (i. e., the series twice interrupted).......*Deromyia discolor* (p. 384).

7. Lateral cephalic process with 5 distinct thorns................. ....*Ceraturgus cruciatus* (p. 379).

— Lateral cephalic process with 4 distinct thorns................. ....*Dasyllis* sp.? (p. 382).

— Lateral cephalic process with 3 distinct thorns.................8

8. A pair of strong bristles at middle of seventh ventral abdominal segment situated slightly caudad of the transverse series (sometimes also distinguishable on sixth) (*Erax*).................9

— Armature of seventh ventral abdominal segment consisting either of a complete transverse simple series of bristles or of a centrally interrupted series, caudad of which there is no armature on the segment..10

9. The pair of thorns at base of middle leg very short and stout; post-spiracular area of first abdominal segment with 7–9 spines; up-

per pair of thorns on apical segment directed upward..........
..................................*Erax maculatus* (p. 387).

— The pair of thorns at base of middle leg rather long and slender; postspiracular area of first abdominal segment with 3 spines; upper pair of thorns on apical segment directed upward and backward, their apices slightly curved downward..............
..................................*Erax aestuans* (p. 388).

10\. Abdominal spiracles only moderately elevated; lateral cephalic process without a distinct protuberance on under surface at base of lower thorn; upper thorn on apical abdominal segment short, directed upward...11

— Abdominal spiracles much elevated; lateral cephalic process with distinct protuberance on under side at base of lower thorn; upper thorn on apical abdominal segment long, directed backward and slightly upward, its apex deflected downward............12

11\. The pair of thorns at base of middle leg-sheath, in front of wing, obtuse at apices.........*Proctacanthus philadelphicus* (p. 385).

— The pair of thorns at base of middle leg-sheath, in front of wing, acute at apices................*Proctacanthus milberti* (p. 385).

12\. The pair of thorns at base of middle leg very short, the larger, posterior one not half as long as lower thorn of lateral cephalic process; seventh ventral abdominal segment with about 14 very long spines in a transverse series which is widely interrupted at center..................................*Asilus notatus* (p. 385).

— The pair of thorns at base of middle leg long, the larger, posterior one as long as lower thorn of lateral cephalic process; seventh ventral abdominal segment with about 24 moderately long spines, the series not noticeably interrupted at center.................
..................................*Asilus sericeus* (p. 386).

With the exception of those species whose descriptions follow, the species in the keys were described in my paper which appeared in 1915*, to which students are referred for descriptions and other details.

Leptogaster flavipes Loew

Leptogaster flavipes Loew, Berl. Ent. Zeitschr., 1862, p. 193.

Larva.—Length, 9 mm. White, semitransparent, glossy; head parts dark brown.

Head viewed from above (dissected) as in Figure 7, Plate LIII, maxillae with slight downward direction and appreciable curve, maxillary palpi stout, at least twice as long as their diameter; (mandibles and labrum not distinguishable in specimen); dorso-central

*Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. IV.

cephalic extension simple, its sides subparallel; lower, lateral cephalic extensions much narrower than dorso-central, their chitinized portions about half as long, divergent posteriorly. Thoracic spiracle rather small; each thoracic segment with a long hair on middle of the ventro-lateral line; sides of each abdominal segment except apical two with a large, round, convex highly glossy area; ventral surface of the same segments each with a transverse ridge-like elevation about one third from anterior margin, which is declivitous on the posterior surface and serves as a locomotor organ; penultimate, spiracular segment at least as long as ultimate, spiracles located well beyond its middle, their openings longitudinally elongated; dorsal surface of last segment not as high as preceding segment, armed with eight hairs, 2 on each side transversely at middle (1 submedian and 1 lateral) and 4 at apex; apex slightly papilliform.

Pupa (Pl. LIII, Fig. 6).—Length, 7 mm. Yellowish testaceous, slightly shining; cephalic armature and the strong abdominal thorns dark brown.

Cephalic armature weak, consisting of 2 slight elevations on upper central portion, the upper margins of which are carinate in front, the carinae closely approximated centrally; a weaker carinated elevation below the outer extremity of each of the upper pair; 3 small wart-like protuberances in a vertical series on median line, the upper in line with the inner extremity of the lateral protuberances, the lower with the bases of the antennal sheaths; antennal sheaths in the form of 2 moderately elevated ridges which taper to a point and are widely divergent apically; center of face with a small wart-like elevation which is slightly above the transverse line of the tips of the antennal sheaths; 4 long hairs on head—1 on each side of the upper pair of elevations and 1 on each side of face in vertical line with the bases of antennal sheaths and considerably below the level of the apices of these. Thoracic spiracles small, distinctly elevated, openings circular; disc of thorax with 8 long hairs—1 on each side of median line before middle and another beyond middle, and a widely separated transverse pair above base of each wing; wing extending beyond middle of second abdominal segment; apices of fore tarsi extending beyond apices of wings; apical 2 joints of mid, and 3 of hind, tarsi extending beyond apices of wings. First dorsal abdominal segment with 6 slender upright thorns (their apices turned backward) in a median transverse series, a single long hair between these thorns except in the middle pair, and laterad of the outermost thorn 4–5 long hairs; second segment with 5 very long, strong, backwardly curved hook-like thorns, the middle one very powerful, and single long hairs between all of the

pairs of thorns; following segments with similar armature except that there are 6 thorns, which are gradually reduced in strength until on the eighth segment they are very short and not much stronger than the long intervening hairs; lateral extremities of the transverse armature as on first segment; spiracles minute; postspiracular area of each segment with 4 long hairs; ventral segments each with 3 long hairs in a transverse series on each side; apical segment rounded, the terminal processes very small.

The foregoing descriptions are drawn from the exuvia of a male specimen reared by the writer. The larva was obtained at Cottonwood Grove, Urbana, Ill., April 23, 1916, in ground under a rotten log in company with several other dipterous larvae. It pupated May 5, and the imago emerged May 19. The specimen is a male, 11.5 mm. in length, which is a considerable increase over the 7 mm. of the pupa. No data were obtained as to the food of the larva.

The imagines of this species are not uncommon in Illinois.

Ceraturgus Wiedemann

I have before me larval and pupal exuvia of one species of this genus, and describe the species herewith. The larval and pupal stages have not been known hitherto.

GENERIC CHARACTERS

Larva.—I have before me only the cast skin of a larva which, with the exception of the head, is in very poor condition. It is not possible for me to discover the structure of the body, but the head is very similar to that of the larva I have considered as belonging to *Dasyllis*, the principal difference lying in the much less evident notch in the maxilla.

Pupa.—Separable from any other genus in the family that is known to me by the presence of 5 thorns on each antennal sheath. There are no small thorns on sides of face as in *Laphria*.

Imago.—The imagines of this genus are very robust insects, and their build, together with the long and dense black and yellow thoracic and abdominal hairs, gives them much the appearance of small bumblebees. They are predaceous, feeding upon a large variety of insects, including bees.

Ceraturgus cruciatus Say

Dasypogon cruciatus Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 52.

Larva.—Head flattened, the portion which is protrusive somewhat shield-shaped (Pl. LV, Fig. 1); maxillae not very acute at apices, the

notch on outer margin rather small; clear area surrounding palpi much larger than in *Dasyllis* sp.?; posterior rods very compact, appearing as a single broad plate when viewed from above (Pl. LV, Fig. 1).

Pupa (Pl. LIV, Fig. 8).—Length, 17 mm. Yellowish testaceous, armature dark brown.

Upper cephalic thorns strong, much thickened at bases, acute and slightly curved downward at apices, separated by about their own length; lateral cephalic thorns 5 in number (Fig. 8); face unarmed. Thoracic spiracles distinctly elevated, the opening compressed (Fig. 6); spine at base of middle leg and in front of wing-base stout, short, and acute at apex; tubercle above base of wing carinate; wings extending to middle of second segment; apices of fore tarsi extending beyond apices of wings; mid tarsi with pulvilli large, their bases at apices of wings and their apices midway between apices of fore and hind pairs; hind tarsi extending nearly to apex of third segment of abdomen, the puvilli very large. Abdominal spiracles elevated, of moderate size, uniform; basal dorsal segment with 6–8 strong backwardly curved thorns in a transverse series; segments 2 to 8 each with a transverse series of 6 strong thorns, between the pairs of which and for a short distance laterad of the outermost one on each side are 1 or 2 much shorter stout thorns, the apices of which are often bifid or trifid; segments 4–8 have in addition to thorns already mentioned 4 or more long bristles on lateral portions of series; apical segment with 4 subequal thorns, 2 above and 2 below, which project almost straight backward (Figs. 3, 4); postspiracular thorns 4–6 in number; ventral segments 1–3 without armature, the others with bristles in a transverse series near posterior margin, those on fifth and sixth segments sparse, the others very closely placed.

Described from one larval exuvium and two pupae submitted by J. A. Hyslop, which bear the following data: Wolfville, Md., May 14, 1914 (P. 125), and Wolfville, Md., larva collected November, 1913, pupated prior to June 1, 1914, adult emerged June 18, 1914.

Dasyllis Loew

I have before me a young larva which I consider as probably belonging to this genus, and a full-grown larva, portions of a larval exuvium, and two pupal exuvia,—all of a species that undoubtedly belongs here.

GENERIC CHARACTERS

Larva.—Head large and broad; maxillae with a distinct incision in their outer margin near the middle; maxillary palpi distinct; surface hairs on head long. Thoracic segments, as figured by Brauer for *Laphria,* longer than the abdominal, the latter more or less distinctly divided transversely, the anterior portion with a circle of 6 wart-like pseudopods; apical segment without chitinized teeth and shorter than subapical in young larva, longer in mature larva, and with a chitinized upper posterior margin bearing 3 teeth.

Pupa.—Distinguished from other asilid pupae by the armature of the head, the antennal sheaths each being quadrispinose.

Imago.—Robust species, usually with conspicuous silky hairs on abdomen.

HABITS OF LARVAE

The larvae live in decaying wood, usually in standing trees, and prey upon Coleoptera and other wood-boring insects. The very strong cephalic armature of the pupa serves to cut a way to the surface in time for the emergence of the imago, even in trees whose wood is hard.

HABITS OF IMAGINES

The imagines have a preference for sitting in the sunshine on exposed tree-trunks and fence-posts. They are predaceous, but occasionally are found on flowers. They attack large Diptera and Hymenoptera, victimizing even wasps and hive-bees.

Dasyllis sp.?

Larva (immature).—Length, 10 mm. Head (Pl. LIV, Fig. 12) broad and flat, maxillary incision of moderate depth; maxillary palpi slender, 2-jointed; mandibles short, not surpassing basal third of maxillae; dorsal posterior rod about 5 times as long as broad, of almost uniform thickness, slightly arcuate transversely; the paired lower rods slender. First thoracic segment much longer than the others. Each dorsal abdominal segment except the apical 2 with 4 pseudopod-like protuberances in a transverse series, the same ventral segments each with 2 such protuberances; transverse division of segments not distinct; apical segment rounded, no chitinized margin evident.

Described from a specimen obtained in woods at Urbana, Ill., April 12, 1892 (McElfresh and Snow).

The larval stage of a great majority of the larger Asilidae lasts over two years, and the specimen above described is evidently a first-year larva, as the structure of the maxillae and the form of the body diverge from the normal form for mature larvae.

Dasyllis sp.?

Larva.—Length, 24 mm. White, with head, a large portion of dorsum of prothorax, and apex of last segment black.

Head very broad, the exposed portion, when seen from above, broader than long; maxillae trilobed owing to the presence of 2 distinct notches on the outer margin, the anterior one being very sharp, the posterior one slightly rounded and not so deep; apices of maxillae blunt; maxillary palpi distinctly 2-jointed, basal joint stouter and a little shorter than apical, the latter about twice as long as thick; mandibles very short, not extending beyond middle of maxillae; antennae indistinguishable; surface hairs strong but not very long. Prothorax with a brownish area on dorsum, the surface of which is studded with numerous small black chitinous spots; dorsal surface of thoracic segments finely striated; prothorax longer than metathorax; ventral hairs strong. Abdominal segments 1–6 each with an encircling series of pseudopod-like processes on their posterior half; penultimate, spiracle-bearing, segment distinctly shorter than ultimate; dorsum of last segment with 4 strong hairs in a curved transverse series just caudad of the depressed segment, and a chitinized plate at tip which is furnished with 3 short teeth and has a short hair ventrad of each lateral tooth; ventral surface of apical segment with 2 long hairs about middle and 2 near tip.

Pupa (Pl. LIII, Fig. 8).—Length: male 13 mm.; female, 25 mm. Brownish testaceous, distinctly shining; armature and wings dark brown.

Upper cephalic thorns strong, gradually tapered from base to apex, separated at apices by more than their own length; lateral cephalic armature consisting of 4 stout thorns; a short stout thorn on lower anterior eye-margin, and a smaller one on anterior portion of cheek; face as in Figure 1, Plate LIV. Thoracic spiracles very little above the level of thoracic dorsum, the aperture reniform, the area laterad of spiracle distinctly striate and with an irregular depression; thorns at base of middle leg 3 in number, flattened and highly polished; protuberances at base of wing in the form of a sharp thumb-nail-like vertical carina; apices of fore tarsi falling far short of apices of wings; apices of mid tarsi extending to apices of wings in male, slightly beyond them in female; claws and pulvilli of hind

tarsi very large, extending for their entire length beyond apices of wings and to base of third abdominal segment. Dorsal abdominal segments 1–7 each with a transverse series of short, stout, closely placed teeth, the lateral extremities of each series replaced by a series of 4–6 bristles; eighth segment with a widely separated pair of stout thorns; postspiracular bristles 4–5 in number, of very uneven strength, the lower one usually much stronger and longer than the strongest of the others; spiracles very slightly raised, openings almost round; apical segment with 4 slightly claw-like thorns, the upper pair much more widely separated than the lower; ventral segments each with a transverse series of bristles, the series becoming progressively stronger to eighth segment; apical segment unarmed ventrally.

The foregoing larval description was made from a specimen without data submitted by Dr. Edna Mosher for identification. The pupa was described from the exuvia of a male and female taken at White Heath, Ill., June 11, 1916. I found the specimens projecting from the decayed base of an apple-tree in a yard belonging to F. M. Peel. I did not find any imagines. June 2 I found one pupal skin in this locality, which I unfortunately lost, but as no others were visible on that date, the imagines must have emerged from the described exuvia during the interval from June 2 to June 11.

Adhering to the apical segment of one of the pupae, I found a portion of the larval exuvium. Unfortunately the head is missing, as is also a portion of the caudal extremity, but there is no doubt that the larva I have described here is that of this species, as there is a portion of the apical segment of the exuvium which agrees with that of the described larva.

Promachus Loew

I have before me the larvae of two species of this genus and the pupae of three, as listed in the foregoing keys. I can not give a summary of larval characters that can be depended on to separate the species of this genus from all other Asilidae, but the pupae are readily identified by the form of the thoracic spiracles, which have no elevated, well-defined reniform area, thus differing from all other genera known to me.

Promachus fitchii Osten Sacken

Promachus fitchii Osten Sacken, Cat. Descr. Dipt. N. A., sec. ed., p. 234. (1878)
Trupanea apivora Fitch, Third Rep. N. Y. State Ent., p. 251. Preoccupied. (1859)

The larva of this species differs very greatly from that of *P. vertebratus*, being comparatively short and stout, with the segments very

much broader than long, whereas the segments in *vertebratus* are longer than broad (Pl. LIV, Fig. 9). The head also differs from that of the latter, as is shown in Figures 5 and 13, Plate LIV.

The pupae of the two species are very much alike in general structure, but may be separated as indicated in key. I have dealt with this stage of the three species known to me in a recently published paper*.

Larvae and pupae of this species were submitted by Dr. E. P. Felt from New York State, and others in our collection are from northern Illinois. All the specimens were obtained where white-grubs were common, on which the larvae were observed feeding. They undoubtedly do much good in reducing the numbers of these grubs, thus more than offsetting the damage done by the imagines in destroying hive-bees.

Deromyia Philippi

I have the larva of one species of this genus and the pupae of two. The larva closely resembles that of *Promachus fitchii* in general appearance, but differs noticeably in the structure of the head, as shown in Figures 11 and 5, Plate LIV. The maxillary palpi are shorter than in *Asilus notatus*, and the apical segment is less distinctly carinated on its upper posterior margin. The armature of the thorax and the apical segment is similar to that of *Asilus* and *Promachus*.

The pupae differ from those of other asilids known to me in the characters given in key.

Deromyia discolor Loew

Diogmites discolor Loew, Berl. Ent. Zeitschr., 1866, p. 21.

Larva.—Length, 25–30 mm. White, head and spiracles blackish brown.

Head normal in size, the exposed portion as in Figure 11, Plate LIV. Segments not as long as broad, those of abdomen with distinct elevations on their anterior third which are in the form of rather pronounced pseudopods. Prothoracic and anal spiracles large, the lateral metathoracic and abdominal pairs very small. Apical segment not sharply carinated, much longer than the segment which bears the spiracles.

Pupa (Pl. LIV, Fig. 7).—Length, 25 mm. Brown, slightly shining.

---

*A Comparison of the Pupae of *Promachus vertebratus* and *P. fitchii*. Bull. Brooklyn Ent. Soc., Vol. 11, pp. 66–68. (1916)

Differs from the pupa of *winthemi* only in the characters given in key to family. For full description of *winthemi* see paper referred to in paragraph following key.

The foregoing descriptions and comparisons were made from specimens of *discolor* sent to me by J. A. Hyslop from Hagerstown, Md.

The larvae of both species known to me feed upon larvae of Coleoptera that occur in fields and gardens.

Proctacanthus Macquart

I have no identified larvae of this genus before me, but have obtained the pupae of two species—*milberti* Macquart, and *philadelphicus* Macquart—which very closely resemble each other. In my paper referred to at end of key I have given a full description of the pupae of *milberti* which it is unnecessary to reproduce here. The only difference between the pupae of *milberti* and *philadelphicus* that appears to serve as a reliable guide to their separation is found in the form of the pair of thorns above the base of the middle leg in front of the wing.

Both species occur commonly in Illinois. In the larval stage they feed upon white-grubs and other coleopterous larvae in fields and gardens.

Asilus Linné

I have before me the larva of one species of this genus and the pupae of two.

The larva differs from this stage of other genera known to me in having the palpi much longer than broad, the head narrower posteriorly, and the apical abdominal segment slightly but distinctly carinated along its upper posterior margin. These characters may not apply to the larvae of other species of this genus, and I do not suggest that they are invariably applicable.

The pupae are very much alike structurally, but may be separated by the use of the characters stated in the key.

Asilus notatus Wiedemann

Asilus notatus Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 451. (1828)

Larva.—Length, 25–30 mm. White, head and spiracles black.

Head with the protruded portion conical (Pl. LIV, Fig. 10); maxillary palpi more than 3 times as long as broad; antennae distinct.

Body cylindrical, the segments well defined, but little longer than broad, and without well-developed locomotor elevations; apical segment much longer than the one bearing the spiracles, slightly but distinctly carinated on its upper posterior margin and with the normal 8 long hairs—4 on dorsum and 4 on venter.

The foregoing details were obtained from specimens I obtained at White Heath, Ill., in April, 1916, some of which produced imagines in May. The larvae occurred in a much-decayed tree-stump in a wood along the Sangamon River. In the same stump occurred many larvae of *Rhamphomyia dimidiata* Loew, and also various coleopterous larvae, the latter including Elateridae, Tenebrionidae, Cerambycidae, and a few others that are usually found in rotten wood.

The pupa I described in the paper mentioned just after the family key.

ASILUS SERICEUS Say

Asilus sericeus Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 48.
Asilus herminius Walker, List of Ins. Brit. Mus., Dipt., Vol. 2, p. 410. (1849)

Pupa.—Length, 20 mm. Brownish testaceous, head and thorax very distinctly shining, abdomen less so, armature and spiracles deep brown.

Upper pair of cephalic processes stout, acutely pointed, apical half of dorsal surface smooth, basal half longitudinally, coarsely striate, bases irregularly rugose; viewed from above, processes slightly divergent apically, the distance between them at apices about equal to length of either thorn; lateral cephalic process as in Figure 2, Plate LV, the projection on under surface of base of lower thorn rather large; lateral pieces of mouth-parts not carinate at apices, the upper, central portion with a distinct protuberance. Thoracic spiracle very much elevated, apex compressed, the whole presenting the appearance of a short compressed tube; the pair of thorns at base of middle leg contiguous basally, anterior one very much smaller than posterior, the latter as large as lower thorn of lateral cephalic process (Fig. 3); protuberance above wing-base with a small chitinized process on lower portion of posterior margin; wing with very faint indications of discal protuberance; apices of wings extending to apices of fore tarsi. Abdominal spiracles similar in form to those of thorax but smaller; first dorsal segment with 12 stout, upwardly directed thorns the apices of which are slightly turned backward; segments 2–7 each with 6 long, stout, acutely pointed thorns, and between the pairs on second segment are either 1 or 2 shorter stout thorns which are not less than half as long as the large thorns, the latter becoming progressively

longer from first to seventh segment, and the short thorns progressively shorter and less numerous; laterad of the outer long thorn on each segment are 1 or 2 short thorns and from 4 to 7 long bristles; eighth segment with 4 short, stout thorns; postspiracular area of first segment with 7–8 bristles; ventral segments up to and including 7 each with a continuous transverse median series of closely placed bristles, the median pair appreciably stronger than those on either side of them; eighth segment with a pair of stout bristles on each side of disc; upper pair of thorns on apical segment long, tapering, directed backward and slightly upward; median pair not half as large as upper, ventral pair short (Pl. LV, Fig. 10).

The foregoing description is drawn from the pupal exuvium of a female obtained at Saratoga Springs, N. Y., June 8, 1915, and kindly submitted by Dr. E. P. Felt.

The species is represented by imagines from Algonquin and Albion, Ill.; and from Hot Springs, Ark.

The habits of the larvae are unknown to me.

Erax maculatus Macquart

Erax maculatus Macquart, Dipt. Exot., Vol. 1, Pt. 2, p. 111. (1838)
Erax lateralis Macquart, ibid, p. 116.
Erax ambiguus Macquart, ibid, Suppl. 1, p. 84. (1845)
Asilus interruptus Macquart, Hist. Nat. Dipt., Vol. 1, p. 310. (1834)

Pupa.—Length, 20 mm. Yellowish testaceous, slightly shining; cephalic and abdominal armature glossy dark brown; apical portions of mouth-sheath and of wings brown.

Upper pair of cephalic processes stout, flattened and smooth above, rugose basally, distance between apices of thorns slightly exceeding length of either thorn; lateral processes consisting of 3 almost equally long blunt thorns, the lower with a slight angle at base on under side (Pl. LV, Fig. 4). Thoracic spiracle very broad, slightly elevated, reniform area smooth and slightly convex, margin carinate; the pair of thorns at base of middle leg very short and stout, about twice as long as their apical width (Fig. 5); protuberance above wing-base with a slight but distinct tooth near its lower posterior margin; wing with a small, sharp, discal protuberance at middle; leg-sheaths with a slight callosity near middle; apices of wings extending to midway between apices of fore and mid tarsi, apices of tarsi carinate on center of ventral surface. Abdominal spiracles broad, not twice as high as breadth at middle, slightly elevated; transverse armature of first

dorsal segment consisting of about 12 strong, upwardly directed, slightly backwardly turned thorns; second segment with 6 shorter, stronger thorns, between each pair of which are 3–4 very short, stout thorns, and laterad of the outermost of the long thorns are 4–5 short thorns and 6–7 long, slender spines in a transverse series which extends to postspiracular series; segments 3–7 as second except that the short thorns decrease in number progressively towards seventh and are almost indistinguishable on the latter; eighth segment with 2 long, widely separated thorns and laterad of these 2 short thorns and 1–2 spines; postspiracular area of first segment with 8–10 spines; each ventral segment with a transverse series of closely placed bristles on middle; sixth and seventh segments each with a strong pair of bristles slightly caudad of the regular transverse series, the pair on seventh segment very noticeably stronger than the other bristles; apical segment with the upper thorns broad, short, flat, and somewhat leaf-like, median thorns small (Pl. LV, Fig. 8).

The foregoing description is drawn from the pupal exuvium of a male obtained by C. G. Ainslee at Orlando, Fla., and kindly submitted for examination by J. J. Davis, of the U. S. Bureau of Entomology (Webster No. 10861 A).

The species is represented in our collection by imagines from Carbondale, Thebes, Metropolis, and Pulaski, all in the southern portion of Illinois; and by one specimen from Virginia.

The larva is predaceous upon white-grubs.

Erax aestuans Linné

Asilus aestuans Wiedemann, Dipt. Exot., Vol. 1, p. 200. (1821)

Pupa.—Length, 18 mm. Yellowish testaceous, slightly shining; armature dark brown, glossy; apices of wings slightly browned.

Upper pair of cephalic processes sharp at apices, not noticeably flattened above; seen from above, slightly divergent apically, the distance between their apices distinctly greater than length of either thorn; lateral process with thorns sharper than in *maculatus* (Pl. LV, Fig. 6); apices of mouth-parts carinate. Thoracic spiracle much smaller than in *maculatus*, and more elevated, the reniform area slightly concave; pair of thorns at base of middle leg slender, sharp, the anterior one less than two thirds the length of the posterior (Fig. 7); protuberance above base of wing similar to that of *maculatus;* protuberance on middle of disc of wing very small; apices of wings extending midway between apices of fore and mid tarsi. Abdominal

spiracles large, slightly elevated; first dorsal segment with 14 long, slender, upwardly directed thorns, the apices of which are slightly deflected backward; segments 2 and 3 each with 6 long, slender thorns, between the middle and outer pairs of which, in each series, are 2 very short, stout thorns, and between the other pairs 1 such thorn, while laterad of the outermost large thorn on each segment are 4–5 short thorns and 4–6 long stout bristles; segments 4–7 each with 6 long spines as on 2 and 3, but the intervening short thorns are, except between the middle pair, reduced to 1, and those on lateral areas are also reduced in number until on segment 7 there are only 2 thorns and 4 bristles laterally; eighth segment with 1 spine and 1 bristle close to lateral margin well distad of transverse median line; armature of each side of apical segment consisting of a strong upwardly and backwardly directed thorn, the apex of which is slightly deflected, a moderately large median lateral thorn, and a small thorn on posteroventral margin (Fig. 9); postspiracular area of first segment with 3 bristles, number on other segments 4–6; ventral segments each with a continuous transverse series of bristles near posterior margin, that on seventh segment consisting of about 24, and slightly caudad of the latter series is a pair of much stronger bristles, one on each side of median line.

The foregoing description is drawn from the pupal exuvium of a male submitted by J. A. Hyslop, of the U. S. Bureau of Entomology (Accession No. 2265).

The species is represented in our collection by imagines from Algonquin, Grafton, Quincy, Urbana, and Mt. Carmel—all in Illinois; and from Delaware Co., Pa., and from Kansas.

The larvae are predaceous upon white-grubs.

Family *BOMBYLIIDAE*

FAMILY CHARACTERS

Larva (Pl. LVI, Fig. 1).—Very few of the species of this family are known or described in the larval stage, and the short characterization that is given here will in all probability require considerable modification to cover the entire family. The young larva of *Bombylius pumilus* has been described by Nielson*, and differs very markedly from the mature form, being very active, and armed with thoracic and anal hairs, which are absent from the latter. Throughout this paper I have dealt only with last-instar larvae, and this point

*Zool. Jahrb., Abth. Geogr. u. Biol., Vol. 18, 1903, p. 647.

must be borne in mind when using the keys to this stage. *Bombylius* is parasitic, or, speaking more precisely, inquilinous, in the nests of the bee genus *Andrena*, and in the larval metamorphosis from an active initial instar to a series of inactive instars presents an analogy to *Melöe*, a beetle which lives under similar conditions. Structurally the larvae of Bombyliidae closely resemble those of Asilidae, but, as far as my limited material permits me to determine, may be separated from the larvae of that family by the much smaller head with a slightly chitinized dorsal projection which is flattened anteriorly as shown in Figure 2, Plate LVI, by the normally crescentic form of the entire body, the head and the apex of the abdomen being slightly recurved ventrally, and by the absence or reduction in size of the thoracic and apical abdominal hairs. I have been able to detect the presence of thoracic hairs in some larvae of Bombyliidae, and Chapman has recorded their presence in the European species *Bombylius major*. He makes no mention, however, of apical abdominal hairs, and Nielson distinctly states that neither thoracic nor apical abdominal hairs are present in *Bombylius minor*. I have found no apical hairs on any of the larvae. The spiracles are small, the anal pair located upon the penultimate abdominal segment and difficult to distinguish; the lateral abdominal pairs are absent.

Pupa.—Like the larva, the pupa resembles that of the Asilidae in its general appearance, but as far as I have seen there is invariably present upon the central portion of the head-capsule, towards its lower margin, a pair of stout thorns which are in some species very closely approximated, or even fused except at apices. The only exception I know of is *Toxophora virgata* as described by Townsend, but the armature of the abdomen is typical of this family. Most of the Asilidae which I have reared or have before me have at least 3 strong thorns upon each antennal sheath, whereas I have found no bombyliid that has more than 2. This character can not be depended upon for the separation of the families, however, as *Leptogaster flavipes*, an asilid, has no thorns on the antennal sheath.

Imago.—The imagines of this family should be readily located in the family by the use of the synoptic key on a previous page. Williston's "Manual" presents a very good key to the genera.

HABITS OF THE LARVAE

All the species that are known in the larval stages are predaceous, parasitic, or inquilinous. A brief summary of the species attacked by the different genera follows. *Argyramoeba* occurs in the nests of

various Hymenoptera-Aculeata, including the genera *Anthophora, Megachile, Hoplomerus, Cemonus, Osmia, Trypoxylon* and *Odynerus; Hemipenthes* (*Anthrax* sens. Osten Sacken) is a hyperparasite, attacking hymenopterous parasites (*Ophion, Banchus*) and dipterous parasites (*Masicera*) of cutworm larvae; *Chrysanthrax fulvohirta* is a hyperparasite, the larva living in *Elis sexcincta,* a parasite of white-grubs; *Anthrax* sens. lat. parasitizes Lepidoptera in the larval stage, generally emerging when the host has pupated, *Mamestra, Panolis, Noctua, Agrotis,* and *Dichromia* being attacked—these records pertaining as far as I am aware to the subgenus *Hyalanthrax*; while the group containing the species with maculate wings attack hymenopterous and dipterous parasites of Lepidoptera, including *Masicera, Ophion,* and *Banchus. Aphoebantus* is predaceous on the egg-masses of the locust *Caloptenus spretus. Systoechus* and *Anastoechus* are also predaceous on locust's eggs, the former being reared in this country from the egg-masses of *Caloptenus spretus. Bombylius* occurs in the nests of the bee genera *Andrena, Halictus, and Colletes. Toxophora* occurs in the nests of *Eumenes, Pelopoeus,* and *Odynerus. Spogostylum* is parasitic upon five genera of Hymenoptera—*Pelopoeus, Megachile, Cemonus, Osmia,* and *Xylocopa*—and two genera of Coleoptera—*Cicindela* and *Calicodoma. Callostoma* feeds upon the egg-masses of *Caloptenus spretus. Exoprosopa fascipennis* is a hyperparasite of the wasp *Tiphia. Sparnopolius fulvus* is parasitic on white-grubs.

HABITS OF THE IMAGINES

The imagines are without exception flower-frequenting, none of them, so far as is known, being predaceous. They are remarkably quick on the wing, their flight consisting alternately of quick dashes, in which the eye can barely follow them, and soaring pauses in mid-air. Their movements in settling upon a flower are very deliberate, but upon being disturbed they depart with a startling rapidity. A very large percentage of the species have the body covered with dense variegated pile, and the wings are very frequently marked with black or brown.

Key to Pupae

1. Upper central pair of cephalic processes thorn-like, widely separated for their entire length; lateral cephalic process or processes thorn-like, but little if any shorter than the central pair......2
— Upper central pair of cephalic processes stout, not thorn-like, contiguous for the greater portion of their length; lateral cephalic processes tubercle-like, much shorter than the central pair.....13

2\. Apical abdominal segment terminating in a pair of long, tapering, backwardly directed thorns; first abdominal segment with the postspiracular hairs as long as head and thorax combined (*Spogostylum*) 3

— Apical abdominal segment usually more or less truncated and with an upwardly and backwardly directed upper process and one or two smaller protuberances below it; first abdominal segment with the postspiracular hairs much shorter than head and thorax combined 5

3\. Head with 4 long thorns on upper anterior margin, the lower one on each side with a small protuberance at base on under side; the pair of thorns on lower portion of central line of face large, their bases contiguous; hairs on head and thorax very long; laterad of the short thorns the transverse armature of dorsal abdominal segments 2–6 consists of 2–3 long, widely placed rounded hairs..... ....*Spogostylum anale.*

— Head with 6 short, stout thorns on upper anterior margin........4

4\. The pair of thorns on lower portion of central line of face small, their bases subcontiguous; hairs of abdomen, except those of verse armature of dorsal abdominal segments 2–6 consists of 12–20 long, closely placed, flattened hairs.......................... ....*Spogostylum simson* (p. 393).

— The pair of thorns on lower portion of central line of face large, their bases, subcontiguous; hairs of abdomen, except those of basal segment, normal......*Spogostylum albofasciatum* (p. 395).

5\. Antero-lateral margins of head each with 1 strong thorn, upper anterior margin with 2 such thorns, making 4 in all; labrum with a bifid thorn..........................*Chrysanthrax fulvohirta.*

— Antero-lateral margins of head each with 2 strong thorns, upper anterior margin with 2 such thorns, making 6 in all...........6

6\. Labrum with a strong bifid thorn; wing with a median subcostal protuberance..............................*Aphoebantus mus.*

— Labrum unarmed..7

7\. The stout thorns on dorsal abdominal segments turned up at bases and apices..8

— The stout thorns on dorsal abdominal segments turned up at apices only..11

8\. Lower lateral cephalic thorn with a palp-like organ projecting on its under surface at base, the apex of which is armed with several hairs..*Bombylius.*

— Lower lateral cephalic thorn without a palp-like organ on under surface..9

9\. Apical 3 segments without the dorsal transverse series of short thorns, armed only with slender hairs; no slender hairs interspersed between the short thorns of median portion of series on other segments..........................*Argyramoeba oedipus.*

— At least the penultimate and antepenultimate segments with dorsal transverse series of short thorns; slender hairs interspersed between the short thorns on all segments......................10

10. Wings extending to apex of third abdominal segment, their color pale..................................*Systoechus oreas.*

— Wings extending short of apex of second abdominal segment. fuscous apically........................*Exoprosopa fasciata?*

11. Transverse armature of first abdominal dorsal segment consisting of a series of short, stout thorns on middle portion, and a number of long, slender, closely placed hairs on each side...*Exoprosopa fascipennis.*

— Transverse armature of first abdominal dorsal segment consisting of a few widely placed hairs, the middle portion either entirely bare or with very slight indications of small tubercles which do not appear as distinct thorns..............................12

12. Lower one of the pair of lateral cephalic thorns simple apically, but with a small wart-like protuberance at base on lower surface, the small wart bearing 2 distinct hairs; wings without discal protuberances..............................*Sparnopolius fulvus.*

— Lower one of the pair of lateral cephalic thorns with a short subapical protuberance, the apex of thorn turned upward, base simple; wings each with a pair of protuberances, one about one fourth from base and the other near middle......*Anastoechus nitidulus.*

13. No well-developed pair of thorns on lower median portion of face...*Toxophora virgata.*

— A well-developed pair of thorns on lower median portion of face.14

14. Eighth ventral abdominal segment without hairs on disc..*Hyalanthrax hypomelas.*

— Eighth ventral abdominal segment with hairs on disc...........15

15. Eighth ventral abdominal segment with 2 hairs on each side of disc; distance from the pair of thorns on lower central portion of head to apex of basal portion of sheath of mouth-parts about 4 times as great as distance from the latter to apex of proboscis...*Hyalanthrax lateralis.*

— Eighth ventral abdominal segment with 10–12 long hairs on disc; distance from the pair of thorns on lower central portion of head to apex of basal portion of sheath of mouth-parts about twice as great as distance from the latter to apex of proboscis..*Hyalanthrax alternata.*

Spogostylum simson Fabricius

Anthrax simson Fabricius, Syst. Antl., p. 49. (1805)

Spogostylum simson (Fabricius) Wiedemann, Dipt. Exot., Vol. 1, p. 122. (1821)

Pupa.—Length, 20 mm. Brownish testaceous, slightly shining; cephalic and abdominal thorns dark brown.

Head with 6 short, stout thorns on upper anterior margin, central pair more widely separated than the others, so that the whole appears as if divided into 2 groups of 3 each; the lower 2 thorns in each group apparently on a single base (Pl. LVI, Fig. 6); the pair of thorns on lower portion of central line of face almost conical, widely separated at base; 4 short hairs above base of upper cephalic thorns and one on each side of the lower central thorns. Prothoracic spiracles circular, rather large, margined with minute radiating rugae; metathoracic spiracles indicated by a small elevation; the normal thoracic hairs present; wing-cases without discal protuberance. Transverse armature of first dorsal abdominal segment consisting of a large number of closely place flattened hairs, which are at least as long as head and thorax combined; dorsal segments 2–6 with the median portion of the transverse armature consisting of a number of short stout thorns which are turned up at bases and apices, giving them the appearance of furcate thorns with one point directed caudad and the other cephalad; seventh segment with 2 short simple thorns on each side of median line; laterad of the thorns on all segments are a number (12–20) of long flattened hairs which are very closely placed; postspiracular hairs very long, and, like the others, minutely pubescent; ventral segments each with 2–4 long flattened hairs in a transverse series on each side at middle; eighth segment with 4 hairs, one dorso-lateral and one latero-ventral on each side; apical segment terminating in 2 long, stout, slightly divergent, acutely pointed processes (Figs. 5, 7).

Described from a specimen submitted by W. L. McAtee which was obtained from a burrow of *Xylocopa virginica* in a pine-roofed porch at Plummers Island, Md., July 31, 1910.

Osten Sacken says of this species, without indicating his authority, "said to be a parasite of *Xylocopa virginica* in the United States"*; and Davidson has recorded it as a parasite of *Xylocopa opifex* at Los Angeles, Calif.†

Xylocopa virginica occurs in the southern half of Illinois, the most northerly record we have being Charleston; and *simson* is represented in our collection by examples from Thebes, Grand Tower, and Grafton—all in the southern half of the state.

---

*Biol. Cent. Amer., Vol. 1, p. 100. (1886)

†Ent. News, Vol. 4, 1893, p. 153.

Spogostylum albofasciatum Macquart

Anthrax albofasciatum Macquart, Dipt. Exot., Vol. 2, Pt. I, p. 67. (1841)
Argyramoeba obsoleta Loew, Berl. Ent. Zeitschr., 1869, p. 29.

Pupa (Pl. LVI, Fig. 3).—Length, 15–17 mm. Yellowish testaceous, slightly shining.

Differs from *simson* in having the pair of thorns on lower central portion of face larger and more closely placed, the clypeus with a sharp carina, the hairs on basal dorsal segment of abdomen flattened and all others slender, those of first segment a little shorter than head and thorax combined, and also in the shape of the apical segment, which at its tip is divided into two rather stout processes, each of which has a short projection on its inner surface near apex, and at the base on each side of segment 2 short thorns, as shown in Figure 4, Plate LVI.

I have seen pupae of this species sent me by Mr. Phil Rau, and a pupa and partly transformed larva submitted by Dr. Edna Mosher. I do not know the locality of the former, but the latter are from New York State.

Imagines of the species are commonly found throughout Illinois, and probably wherever its host, *Pelopoeus cementarius,* is found.

I suspect that several more species names will ultimately be added to the foregoing synonymy, as several species depend upon wing-markings—which are extremely variable—for their separation.

References to Descriptions of Larvae and Pupae of North American Bombyliidae

Spogostylum anale Say, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 328. (1915)

Spogostylum anale Say, Shelford, Ann. Ent. Soc. Amer., Vol. 6, No. 2, 1913, p. 213.

Chrysanthrax fulvohirta Wiedemann, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 67. (1916)

Aphoebantus mus Osten Sacken, Riley, Packard, and Thomas, Sec. Rep. U. S. Ent. Comm., p. 262. (1880)

Systoechus oreas Osten Sacken, idem, ibid., p. 266.

Exoprosopa fasciata Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 329. (1915)

Exoprosopa fascipennis Say, Malloch, ibid., p. 330.

Argyramoeba oedipus Fabricius, Townsend, Am. Nat., Vol. 27, p. 60. (1893)

Sparnopolius fulvus Wiedemann, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 331. (1915)

Anastoechus nitidulus Fabricius, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 68. (1916)

Toxophora virgata Osten Sacken, Townsend, Psyche, Vol. 6, p. 455. (1893)

Hyalanthrax hypomelas Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 334. (1915)

Hyalanthrax lateralis Say, Malloch, ibid, p. 332.

Hyalanthrax alternata Say, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 69. (1916)

Superfamily *Therevoidea*

The superfamily name of Polytoma was used by Brauer to cover the families Therevidae and Scenopinidae. This grouping is followed in the present paper, but the name is changed to Therevoidea to conform to the rules governing zoological nomenclature.

CHARACTERS OF SUPERFAMILY

Larva.—Head with a cone-shaped anterior protruded portion, which consists of a dorsal sclerite overlapping the sides, and a small ventral sclerite which is not fused to the dorsal one; mandibles well developed; antennae and maxillary palpi distinct; dorsal posterior portion of head consisting of but one rod, the lower rods short or apparently absent. Thoracic hairs well developed. Abdominal segments 1–6 divided, the entire body appearing to consist of 20 segments exclusive of the head; anterior spiracles distinct; lateral abdominal spiracles absent; posterior spiracles situated on the antepenultimate segment.

Pupa.—Head with a pair of antennal thorns, which are directed laterad. Thorax with a long thorn at base of wing, or if this is absent the abdomen has 2 transverse series of spines on each dorsal segment except basal and apical.

Imago.—Eyes of males in Therevidae usually contiguous, in Scenopinidae distinctly separated; frons not sunken between eyes; proboscis never elongated. Body with or without wooly hairs; if the abdomen and thorax are somewhat leathery in appearance there are only 3 posterior cells on wing and the third antennal joint has no terminal arista. Legs without hairs or bristles in Scenopinidae, with or without small bristles in Therevidae.

Family *THEREVIDAE*

FAMILY CHARACTERS

Larva (Pl. LVI, Fig. 10).—Very long and slender, tapering towards both extremities; head small, the posterior internal chitinized

dorsal extension in the form of a single stout rod with spatulate apex; mandibles strong, deflected in front and pointed at apices; antennae of moderate length (Pl. LVII, Fig. 1). Prothoracic spiracle distinct (Pl. LVI, Fig. 9); each thoracic segment with 2 hairs, one on middle of the latero-ventral line on each side. Abdominal segments 1 to 6 divided by means of a distinct circular constriction, so that the body appears to consist of 20 segments; posterior spiracles on antepenultimate abdominal segment; ultimate segment with 2 short points at apex and several surface hairs.

Pupa (Pl. LVI, Fig. 12).—Distinguishable from other pupae of the Brachycera by the presence of 2 thorns (antennal sheaths) on head and a long curved thorn at base of each wing. The abdomen has a single girdle of thorns on each segment, and the apical segment ends in 2 long, slender thorns which are contiguous except apically (Fig. 13).

Imago.—See key to families of Brachycera.

HABITS OF LARVAE

The larvae are found in the ground and also in decaying wood. I have found one species in wheat fields and in woods. They are predaceous, feeding upon various insect larvae, including wireworms, and under conditions of overcrowding or scarcity of other food they are cannibalistic.

HABITS OF IMAGINES

The flies are very active, especially during sunshine, when they may be found frequenting bare paths and sandy or exposed banks. I have no data upon their food habits except that they frequent flowers occasionally.

I have no record of parasitic enemies of any stage.

PSILOCEPHALA HAEMORRHOIDALIS Macquart

Thereva haemorrhoidalis Macquart, Dipt. Exot., Vol. 2, Pt. I, p. 26. Imago. (1841)

Psilocephala haemorrhoidalis Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 334. Larva and pupa. (1915)

This species is the only *Psilocephala* that I have found in Illinois in the larval stage, although a number of other species of the genus are well represented in our collection of imagines. The habits are as previously mentioned for the family; descriptions of all stages are

cited in the above synonymy; and figures of the larva and pupa are given in the present paper (Pl. LVI, Figs. 9, 10, 12, 13; Pl. LVII, Fig. 1).

PSILOCEPHALA MELAMPODIA Loew

Psilocephala melampodia Loew, Berl. Ent. Zeitschr., 1869, p. 9. Imago.
Psilocephala melampodia Loew, Felt, Bull. N. Y. State Mus., No. 155, p. 121. Larva and pupa. (1912)

This species was reared from a larva found under decaying pine bark at Albany, N. Y., April 8, 1911, and the larva and pupa were described by Dr. Felt, as indicated above.

The description of the larva is too short to permit of any comparison with that of *haemorrhoidalis*; but the pupa, judging from the description, has much shorter thorns at base of wing. Only a comparison of the larvae and pupae of the two species will furnish characters for their specific separation.

Family *SCENOPINIDAE*

FAMILY CHARACTERS

Larva.—Closely resembles the larvae of the Therevidae. The smaller size and different habitat of the species readily distinguishes the larvae from those of that family without dissection, and dissection of the head provides characters for the separation of the species known to me. *Scenopinus* has the dorsal posterior chitinized extension parallel-sided apically, whereas *Psilocephala* has it spatulate, and while the latter has a pair of lower chitinized processes projecting beyond the posterior margin of the protruded portion of the head and evidently connected with the mandibles, *Scenopinus* has no such processes. Superficially the larvae are otherwise similar.

Pupa.—The pupa of this family is known to me only from descriptions. It is possible, however, to indicate that the species of the two families so far described may be separated by the character of the armature of the abdominal segments—Therevidae having only the apical girdle of spines on the abdominal segments while *Scenopinus* has an additional one on the middle of each segment.

Imago.—Distinguishable from Therevidae principally by the wing venation.

HABITS OF LARVAE

The larvae of *Scenopinus fenestralis* are predaceous, feeding upon larvae of other insects, and are found in a variety of situations—in fungi, in rotten wood, under carpets in houses, in roots of plants, etc.

HABITS OF IMAGINES

Imagines of a few common species may be collected from windows. They are not predaceous, feeding as far as we have observed upon nectar or moisture.

Scenopinus fenestralis Linné

Musca fenestralis **Linné, Fauna Suecica. (1761)**

Larva.—Length, 18–20 mm. White.

Very slender, tapering towards both extremities. Head conical (Pl. LVII, Fig. 2). Thoracic hairs as long as or longer than the segments upon which they are situated; spiracles distinct (Pl. LVI, Fig. 11). Anterior division of abdominal segments 1 to 6 about one half longer than posterior; posterior spiracle about one third from anterior margin of antepenultimate segment; apical segment divided (Pl. LVI, Fig. 8), the surface hairs long.

The foregoing description was made from specimens obtained at Urbana, Ill., November 3, 1892, under a carpet, where they were feeding upon larvae of *Tinea tapetzella* (C. A. Hart).

The species was not reared and no pupae are available, the characters used in the key and elsewhere in this paper being obtained from published descriptions.

The species occurs commonly both in Europe and North America.

Tribe Orthogenya

This tribe of the Brachycera contains one superfamily, Empididoidea, and two families, Empididae and Dolichopodidae, both of which contain a very large number of species.

Superfamily *Empididoidea*

CHARACTERS OF TRIBE AND SUPERFAMILY

Larva.—The larvae of both families as far as known, differ from others in Brachycera in having the labial plates and the longitudinal rods meeting at right angles, so that in profile they appear bent. The maxillary palpi are usually small and the antennae distinct. In all species that I have examined there are 4 slender elongate posterior cephalic rods, the larvae are amphipneustic, and the locomotor organs are more or less developed, consisting of paired pseudopods, of fusiform ventral areas armed with spines, or of transverse series of short spinules. The posterior spiracles are upon the apical abdominal seg-

ment and well separated, being sessile or nearly so in most species, only rarely elevated; this segment frequently has 4 short terminal protuberances.

Pupa.—The head very rarely has 2 long, strongly chitinized protuberances, and the antennae are short, directed downward and slightly outward, with 2 hairs on slight elevations at bases, and sometimes 2 or 3 short, compressed teeth on basal half. The proboscis in the Empididae that I have seen is much elongated, projecting much farther between the wings than in Dolichopodidae. Brauer has indicated that the former family possesses sessile thoracic respiratory organs, while the latter has these organs pedunculate and slender. I have reared one empid that has the type of respiratory organs which he ascribes to the Dolichopodidae, and this invalidates the structure of the respiratory organs as a differentiating character in these families. The proboscis, as above indicated, may prove useful in separating the families, but I suspect that *Ocydromyia* and several other genera of Empididae that have the proboscis short, can not be separated from Dolichopodidae by that character.

Imago.—Most species of Dolichopodidae are distinguishable at a glance from other Orthorrhaphae by their bright metallic blue or green color and their slender elongate legs. The few genera that are dull in color may be readily separated by their different habitus.

The Empididae are usually blackish or brownish slender species with elongate legs, those of the female frequently possessing a fringe of scale-like hairs on some or all of their tibiae or femora. The proboscis in the great majority of genera in this family is elongate, slender, and fitted for piercing. For synoptic characters see key to imagines of Brachycera.

Family *EMPIDIDAE*

FAMILY CHARACTERS

Larva.—The labial plates and the longitudinal rods of the head meet angularly, so that in profile they appear bent. The labium consists of 2 arcuate bands, which are contiguous and form an angle anteriorly; the mandibles appear in the form of a lunate plate, as shown in Figures 4 and 6, Plate LVII. The antennae are well developed, consisting of 2 joints. The posterior spiracles are situated upon the last segment, well separated and occasionally slightly elevated; the last segment is rounded or has a slight protuberance below at tip.

I have the immature stages of only two genera in my material, and to attempt a generalization of the family and a presentation of the characters for their separation from Dolichopodidae, with which I am almost unacquainted, is impossible.

Imago.—See family key.

HABITS OF LARVAE

The European species are much better known than the American, and from data supplied by workers on that continent, and from my personal observations, it is evident that the larvae are for the most part either predaceous or scavengers, living in the ground or in wood in a more or less advanced stage of decay. Some species are aquatic or semiaquatic.

HABITS OF IMAGINES

The imagines are in the great majority of cases predaceous, feeding upon other insects and occasionally attacking species of the same family or individuals of the same species. There are published records that the male of some genera catches the prey which serves as a meal for the female during copulation. The sexes of *Tachydromia* and allied genera catch their own prey, usually while running on tree-trunks. Many species have a habit of flying in swarms, remaining in one place and flying with an up and down movement similar to that adopted by certain Chironomidae. Terrestrial species usually fly in this manner on the leeward side of a tree, bush, or other sheltering object; but the aquatic forms and those living in damp earth perform their aerial dance over the surface of a pool in a stream, or over a pond or lake.

Despite their predaceous habits nearly all genera occur upon flowers, sometimes in large numbers.

RHAMPHOMYIA DIMIDIATA LOEW

Rhamphomyia dimidiata Loew, Berl. Ent. Zeitschr., 1861, p. 325.

Larva.—Length, 7–9 mm. White, head black. General shape musciform, tapered anteriorly, blunt posteriorly. Head when seen from above, as in Figure 4, Plate LVII; the antennae well developed, 2-jointed. Thoracic spiracles small. Abdomen with 8 segments; circular in cross-section; segments broader than long, without distinguishable locomotor organs, apical segment rounded; spiracles large, disc-like, separated by a space about equal to width of a spir-

acle, spiracular openings irregular; a group of 3–4 hairs on a slight elevation below each spiracle.

Pupa (Pl. LVII, Fig. 5).—Length, 6–8 mm. Yellowish testaceous, the armature brown.

Head without prominent thorns, the bases of antennae produced in the form of carinate ridges; proboscis thick, elongated. Thoracic respiratory organs in the form of short stalks; surface hairs as in figure. Abdominal spiracles elevated; armature as in figure, the bristles rather slender.

The foregoing descriptions were made from material obtained by me at White Heath, Ill., April 2, 1916, from a much-decayed tree-stump. I reared a number of specimens of both sexes under laboratory conditions, the specimens emerging from ten days to three weeks from date of collection of the larvae, the average duration of the pupal stage being 8 days. No parasites were obtained.

No imagines of this species were obtained by collecting in the locality where the larvae were taken, and the species is unrepresented in our Laboratory collection except by the reared examples.

Originally described from Maryland and Massachusetts, the species has not, so far as I know, been subsequently recorded.

Drapetis Meigen

I have seen the larval and pupal exuvia of but one species of this genus, and these are not in very good condition. This species, *nigra* Meigen, is slightly less than 1.5 mm. in length, and as the exuvia were dried out when I found them the details are not as clear as they would be in fresh material. The drawings, however, give a good idea of the general appearance of the parts available for study.

HABITS OF LARVAE

The larvae occur under bark and in decaying wood. Their very small size makes their detection difficult. They spin a remarkably tough cocoon, in which they pupate. The cocoon is densely coated with minute particles of the wood in which the larvae live.

HABITS OF IMAGINES

The imagines are very common on tree-trunks and fences, running with great rapidity, and are predaceous upon small insects. They resemble the dolichopodid genus *Medeterus* in both larval and adult habits.

DRAPETIS NIGRA Meigen

Drapetis nigra Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 6, p. 344. (1828)

Larva.—Length, 2–2.5 mm. White.

Musciform; head from above as in Figure 6, Plate LVII. Abdomen with locomotor spinules in a rather broad band on anterior margin of segments; posterior spiracles large, separated by slightly more than the width of a spiracle; a slightly darkened and raised transversely elongated area below spiracles armed with a few hairs.

Pupa (Pl. LVII, Fig. 7).—The pupa differs in many respects from that of *Rhamphomyia dimidiata.* The chief distinctions lie in the much elongated respiratory organs of the thorax, and in the armature of the abdomen, the latter consisting of a dense covering of small spinules on the greater portion of the dorsum of all segments.

The specimens from which the foregoing descriptions were made, are the exuvia of a female reared from a rotten stump at Crystal Lake Park, Urbana, June 10, 1916. With this specimen were many larvae of *Clusiodes flaviseta* Johnson.

Drapetis nigra is a European species that has previously been recorded from South Dakota and Canada.

PAPERS ON THE BIOLOGY OF NORTH AMERICAN EMPIDIDAE

Aldrich, J. M., and Turley, L. A.
'99. A Balloon-making fly. Am. Nat., 33: 809–812.

Needham, J. G., and Betten, C.
'01. Aquatic insects in the Adirondacks. Bull. 47, N. Y. State Mus. (Notes on the life history and descriptions of larva and pupa of *Roederiodes juncta* Coquillett are given on pp. 581–582.)

Family *DOLICHOPODIDAE*

I have not succeeded in obtaining all stages of any species of this family, and little is known of the early stages in America, only one species in this country being fully described—by Johannsen and Crosby. I have before me the larvae of two species, which were described by Mr. Hart in his paper "On the Entomology of the Illinois River and Adjacent Waters" cited in the list of publications at the close of this section. These larvae were referred to Brachycera without being assigned to any family. The European species are much better known, though few of the descriptions are clear upon many of the essential points. In view of these facts it would be folly to at-

tempt a characterization of the larval and pupal stages of the family, but in pointing out the meagerness of our knowledge I hope I may help to remedy it by directing the attention of some student to this line of investigation, which will repay him more satisfactorily for the time and energy expended than will the writing of new descriptions of imagines the life history of which is entirely unknown.

HABITS OF LARVAE

The larvae have been recorded as predaceous upon other insect larvae. They are found in a variety of situations, but a great majority are aquatic. *Dolichopus*, *Hydrophorus*, and *Campsicnemus* are among the aquatic forms, and *Medeterus* and *Thrypticus* are found in plants, the latter in the stems of low plants, and the former in burrows of other larvae or under bark of trees. The larva of *Aphrosylus* occurs among seaweed on the shore.

HABITS OF IMAGINES

Many of the species occur upon flowers, and several genera, such as *Chrysotus*, *Dolichopus*, and *Psilopus* occur commonly upon leaves of plants. They undoubtedly feed upon nectar, but even *Psilopus* will destroy small insects, as I have seen it catch a small thrips, and though it did not kill it, its actions were such that I am convinced that the species are predaceous. *Medeterus* I have seen feeding upon a specimen of *Forcipomyia*. *Aphrosylus* I know from observation to be predaceous, and *Hydrophorus* and *Campsicnemus* have the same habit.

NOTES ON DESCRIBED SPECIES

The only identified species that has been recognizably described from North America is *Thrypticus muhlenbergiae* Johannsen and Crosby. From an examination of the figures and description of the larva of this species I find that it agrees with that of *T. smaragdinus* Gerstaeker, a European species, in being peripneustic, and in having a transverse band of locomotor spinules on 8 of the ventral segments, the spinules of the anterior series of each band stronger than those of the 2 or more posterior series. The general shape of the European larva is more uniform than that in the figure of the American, but I suspect that the latter represents a specimen just prior to pupation. The cephalic capsule of the pupa of both species is armed with a pair of protuberances, those of *smaragdinus* being strong and stout, while

those of *muhlenbergiae* are slender and almost hair-like. The thoracic respiratory organs in both species are stalk-like. The figure and description of our species give us no details of the legs and wings, but *smaragdinus* is figured as having the wings extending to the apex of second abdominal segment, the apices of fore tarsi to middle of fourth, those of mid tarsi to apex of fifth, and those of hind tarsi almost to apex of abdomen. Both species have a single transverse series of short spines on each dorsal abdominal segment, and pedunculate spiracles on lateral margins of segments 1 to 4. The apical segment in *muhlenbergiae* is armed with 4 thorns.

It will be seen from the foregoing that the pupae offer as characters for distinguishing them from the pupae of *Drapetis* the pedunculate abdominal spiracles and the single transverse series of dorsal abdominal spinules. The larvae I can not fully compare because I have only a cast larval skin of *Drapetis* which affords no evidence as to whether there are lateral abdominal spiracles in that stage. The locomotor spines differ somewhat, however, and if the figure of *muhlenbergiae* is dependable the head also differs in having a single saddle-like dorsal plate.

Both species of *Thrypticus* above mentioned live in stems of plants; neither species forms a cocoon like that of *Drapetis.*

Medeterus lives in burrows of wood-boring larvae and also under bark. Dr. E. P. Felt has recorded the larvae as feeding upon those of *Miastor.* No species of this genus has been described in either the larval or pupal stage from America. Perris has described the larva and pupa of *Medeterus ambiguus,* a European species. The larva of this species has the head very similar to that figured in the present paper for *Drapetis* (Pl. LVII, Fig. 6). The distinctions, judging from Perris's figures, lie in the presence of only one series of locomotor spinules on the abdominal segments, and in the tapering apical abdominal segment, which ends in 4 short subcontiguous points, at the apices of the upper and larger pair of which are located the posterior spiracles. No mention is made of lateral abdominal spiracles, but the prothoracic pair are figured. The pupa has the pair of cephalic spines similar to those of *Thrypticus,* but slightly ventrad of them are 2 much smaller protuberances. The thoracic respiratory organs are long and slender. The fore tarsi do not extend beyond apices of wings, the mid pair reach middle of fourth abdominal segment, and the hind pair extend to middle of sixth. The dorsal abdominal segments possess 2 linear transverse series of spinules.

A species of *Systenus* described by Laboulbène differs in the larval stage from *Medeterus* in having the locomotor spinules situated upon

ventral fusiform transverse areas, and in the shape of the apical segment, the latter being of uniform width to apex, and having 4 short, widely separated protuberances, the lower pair distinctly longer than the upper, the latter bearing the posterior spiracles.

The pupa of this genus resembles closely that of *Medeterus,* but the thoracic respiratory organs are figured as long as head and thorax together, with distinctly tapered apices. The fore tarsi extend beyond the apices of the wings and the dorsal abdominal segments each have a band of locomotor spinules consisting of about 3 series, the anterior one of which is much stronger than the others. Neither *Medeterus* nor *Systenus* has the abdominal spiracles pedunculate.

Brauer figures the larva of *Dolichopus aeneus* De Geer. The head shows an upper T-shaped piece whose anterior portion is considered as the labrum, and on each side of this plate are the sickle-shaped mandibles; the maxillae are not chitinized and their palpi are short and blunt; the antennae consist of 2 joints. The posterior cephalic rods are represented as slender, the upper pair slightly broadened posteriorly and exceeding in length the lower pair. The body is figured with 7 pairs of pseudopods, the apices of which are armed with rather strong spinules. The apical segment terminates in 4 short subequal protuberances.

The pupa has the cephalic capsule with 4 small warts above, and below these 2 others. The thoracic respiratory organs are very long and slender.

The larva of a species of *Dolichopus* is figured herein (Pl. LVII, Fig. 3). This is Larva (*b*) of C. A. Hart's paper previously referred to, which he described at the conclusion of the part dealing with Brachycera. All three species therein referred to are of this genus.

References to Papers on the Biology of North American and European Dolichopodidae

Brauer, F.

Denschr. k. Akad. Wissensch., Wien, math.-naturw. Cl., 47:44. (1883)

Felt, E. P.

Jour. Econom. Ent., 4:414. (1911); Can. Ent., 45:373. (1913)

Grünberg, K.

Die Süsswasserfauna Deutschlands, Heft 2a, Erster Teil, p. 167. (1910)

Hart, C. A.
Bull. Ill. State Lab. Nat. Hist., Art. VI, 4:268–270. (1895)
[Larvae (*a*), (*b*), and (*c*), described without assigning them to any family, belong to the Dolichopodidae.]

Johannsen, O. A., and Crosby, C. R.
Psyche, 20:164. (1913)

Laboulbène, A.
Ann. Soc. Ent. France, ser. 5, 3:49. (1873)

Perris, E.
Ann. Soc. Ent. France, ser. 4, 10:321. (1870)

Wheeler, W. M.
Proc. Calif. Acad. Sci., ser. 3, 1:150. (1897)

Urbana, Illinois, March 16, 1917.

INDEX

(To genera and species described or discussed separately or in family connection, or included in the synoptic keys.)

Plate XXVIII

Larvae and Pupae of Tipulidae and Limnobiidae

Fig. 1. *Tipula eluta,* larva, lateral view.
Fig. 2. *Tipula* sp. 2, larva, lateral view.
Fig. 3. The same, larva, caudal view of apical segment.
Fig. 4. *Pachyrrhina ferruginea,* larva, lateral view of female.
Fig. 5. The same, pupa, dorsal view of apical segment of female.
Fig. 6. The same, pupa, lateral view.
Fig. 7. *Tipula bicornis,* pupa, lateral view of apical segment of male.
Fig. 8. *Tipula serta?*, pupa, lateral view of apical segment of female.
Fig. 9. *Tipula eluta,* pupa, lateral view.
Fig. 10. *Pachyrrhina ferruginea,* pupa, lateral view of apical segment of male.
Fig. 11. *Tipula eluta,* pupa, lateral view of apical segment of male.
Fig. 12. *Pachyrrhina ferruginea,* pupa, palpus.
Fig. 13. *Tipula eluta,* pupa, ventral view of head, thorax, and base of abdomen.
Fig. 14. *Tipula* sp. 1, pupa, lateral view.
Fig. 15. *Gnophomyia tristissima,* pupa, ventral view of head, thorax, and base of abdomen.
Fig. 16. The same, pupa, ventral view of apical segment of male.
Fig. 17. The same, pupa, dorsal view of apical 2 segments of male.
Fig. 18. The same, pupa, ventral view of apical segment of female.

PLATE XXVIII

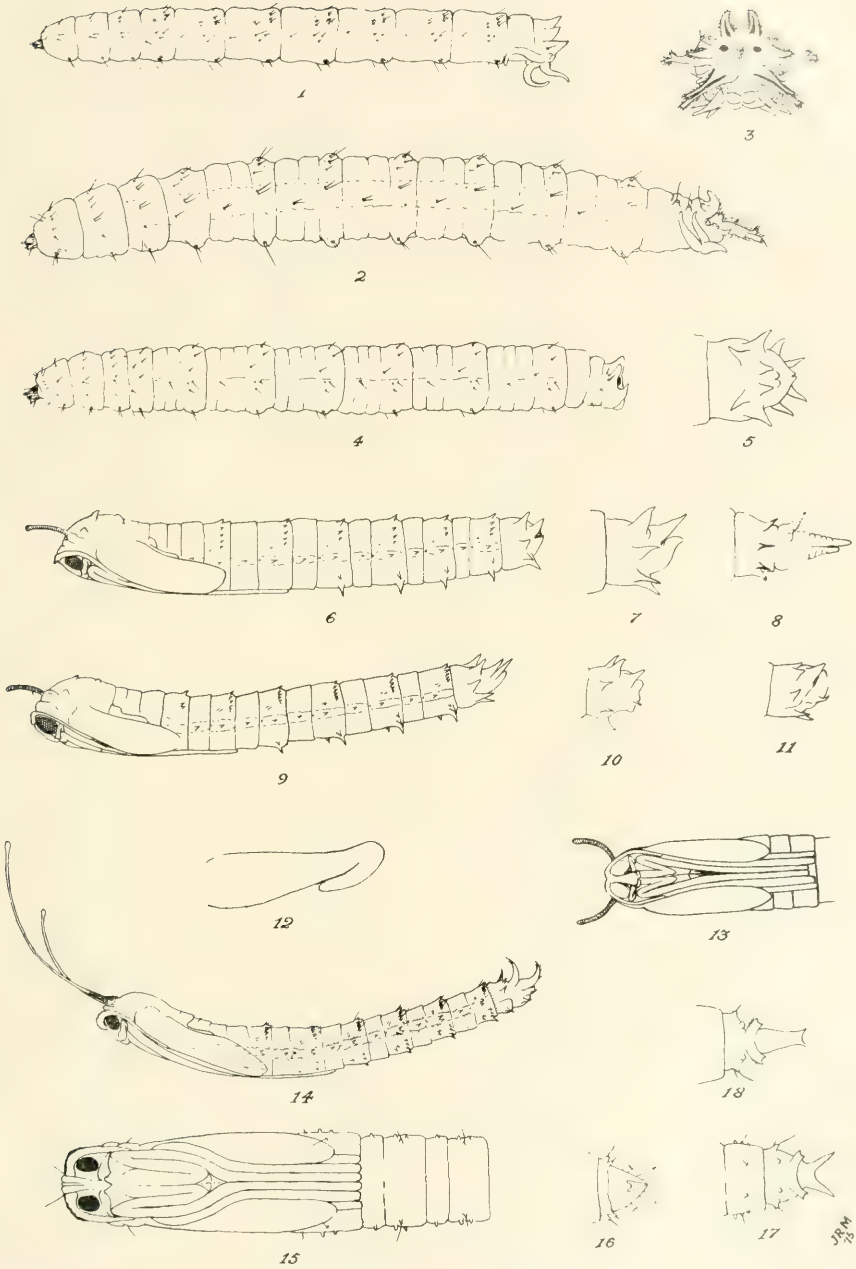


Plate XXIX

Larvae and Pupae of Tipulidae and Limnobiidae

Fig. 1. *Tipula eluta,* larva, dorsal view.
Fig. 2. The same, pupa, dorsal view.
Fig. 3. *Tipula* sp. 5, larva, dorsal view.
Fig. 4. *Limnophila luteipennis,* larva, dorsal view.
Fig. 5. The same, pupa, dorsal view.
Fig. 6. *Helobia punctipennis,* larva, dorsal view.
Fig. 7. The same, pupa, dorsal view.
Fig. 8. *Genus incertus* 3, larva, dorsal view.

Plate XXIX

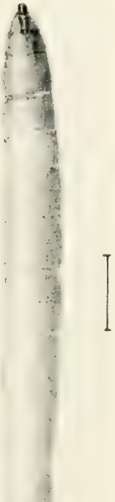
1

2

3

4

5



6

7

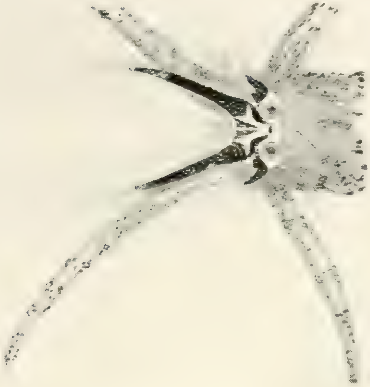
8

Plate XXX

Larvae and Pupae of Tipulidae, Limnobiidae, and Ptychopteridae

Fig. 1. *Limnophila luteipennis*, larva, dorsal view of apical segment.
Fig. 2. *Bittacomorpha clavipes*, larval pseudopod.
Fig. 3. *Pachyrrhina ferruginea*, larva, apical segment.
Fig. 4. *Bittacomorpha clavipes*, larva, lateral view.
Fig. 5. *Genus incertus* 3, larva, apical segment.
Fig. 6. *Bittacomorpha clavipes*, pupa, dorsal view.

Plate XXX



1

2

3

4

5

6

Plate XXXI

Larvae of Tipula

Fig. 1. *Tipula* sp. 7, caudal view of apical segment.
Fig. 2. The same, dorsal view of head, one side.
Fig. 3. The same, ventral view of head, one side.
Fig. 4. *Tipula* sp. 4, dorsal view of fronto-clypeal region of head and antennae.
Fig. 5. The same, caudal view of apical segment.
Fig. 6. *Tipula* sp. 6, dorsal view of apical segment.
Fig. 7. The same, caudal view of apical segment.
Fig. 8. *Tipula* sp. 1, caudal view of apical segment.
Fig. 9. *Tipula* sp. 2, frontal plate of head.
Fig. 10. *Pachyrrhina ferruginea*, frontal plate of head.
Fig. 11. *Tipula* sp. 7, lateral view of hypopharynx, showing oesophageal opening.
Fig. 12. *Tipula* sp. 3, dorsal view of hypopharynx.
Fig. 13. *Tipula* sp. 2, dorsal view of hypopharynx.
Fig. 14. *Tipula* sp. 7, dorsal view of hypopharynx.
Fig. 15. *Tipula* sp. 4, dorsal view of hypopharynx.

PLATE XXXI

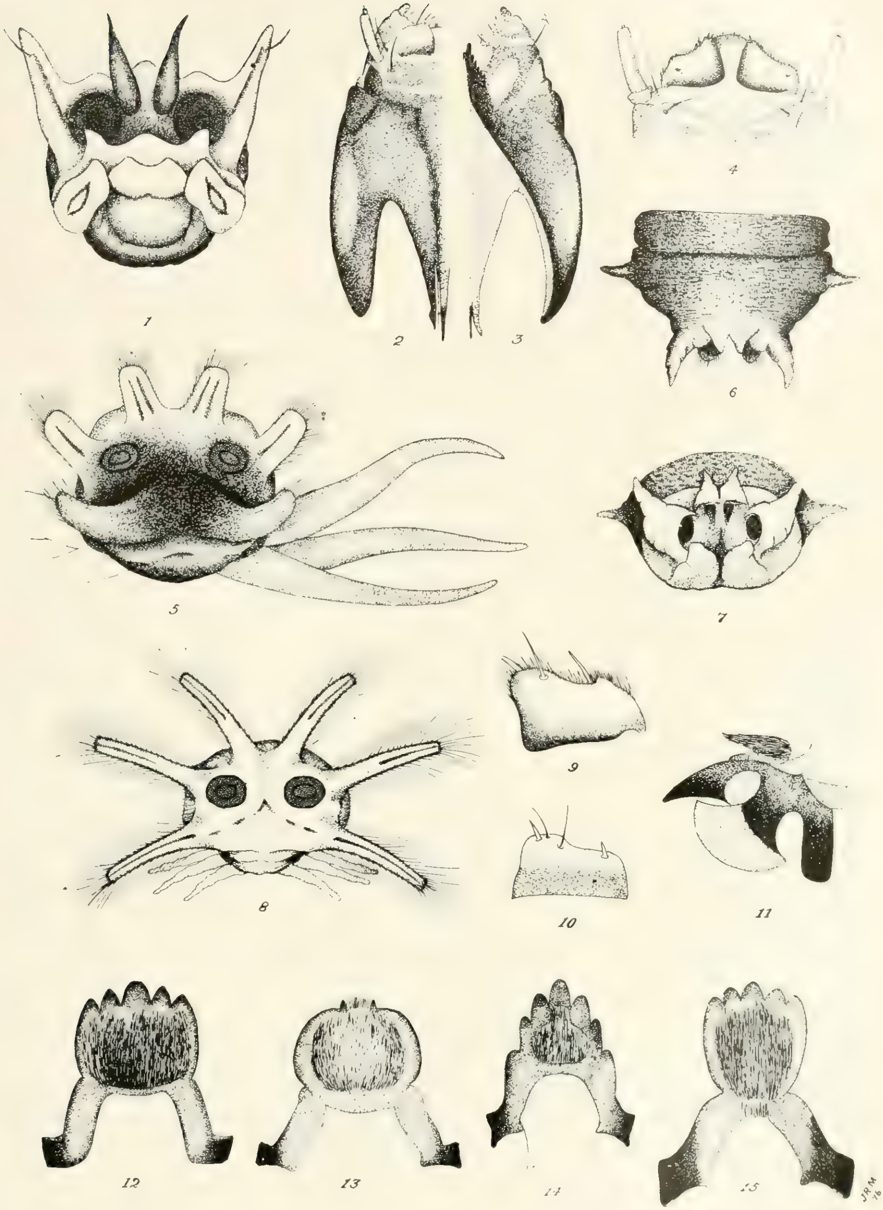


Plate XXXII

Larvae and Pupae of Tipulidae

Fig. 1. *Tipula* sp. 1, hypopharynx of larva, dorsal view.
Fig. 2. The same, mandible of larva.
Fig. 3. The same, labium of larva.
Fig. 4. *Tipula* sp. 3, side view of protruded portion of head of larva: *a*, antenna; *p*, maxillary palpus; *m*, mandible; *l*, labium; *fp*, frontal plate.
Fig. 5. *Tipula* sp. 2, labium of larva.
Fig. 6. *Tipula* sp. 3, labium of larva.
Fig. 7. *Tipula* sp. 5, apical segment of larva, lateral view.
Fig. 8. The same, apical segment of larva, caudal view.
Fig. 9. *Tipula* sp. 4, labium of larva.
Fig. 10. *Tipula cunctans*, labium of larva.
Fig. 11. The same, outline of anterior margin of hypopharynx of larva.
Fig. 12. *Tipula bicornis*, labium of larva.
Fig. 13. The same, outline of anterior margin of hypopharynx of larva.
Fig. 14. *Pachyrrhina ferruginea*, labium of larva.
Fig. 15. The same, outline of anterior margin of hypopharynx of larva.
Fig. 16. *Tipula trivittata*, apical segment of male pupa, lateral view.
Fig. 17. The same, apical segment of female pupa, lateral view.
Fig. 18. *Tipula* sp. 7, apical segment of female pupa, lateral view.
Fig. 19. *Tipula cunctans*, apical segment of female pupa, lateral view.
Fig. 20. *Xiphura fumipennis*, thoracic respiratory organ of pupa.
Fig. 21. The same, antenna of larva.
Fig. 22. *Tipula cunctans*, apex of male pupa, lateral view.
Fig. 23. *Xiphura fumipennis*, hypopharynx of larva, dorsal view.
Fig. 24. The same, pupa, dorsal view.
Fig. 25. The same, mandible of larva.
Fig. 26. *Tipula* sp. 4, mandible of larva.
Fig. 27. *Tipula* sp. 7, mandible of larva.

Plate XXXII

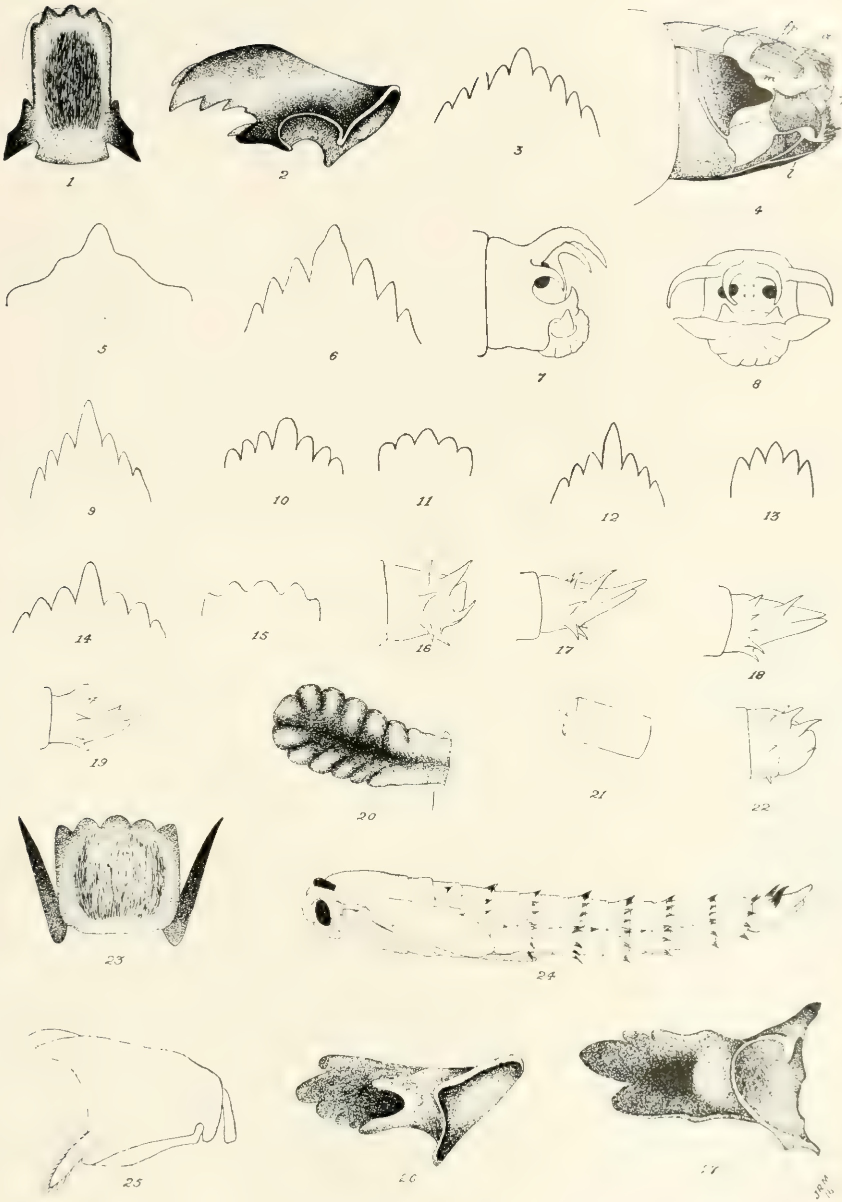


Plate XXXIII

Larvae and Pupae of Limnobiidae

Fig. 1. *Phalacrocera replicata,* larva, dorsal view.
Fig. 2. *Limnophila luteipennis,* antenna of larva.
Fig. 3. The same, labium of larva.
Fig. 4. *Phalacrocera replicata,* pupa, lateral view.
Fig. 5. *Dicranomyia simulans,* thoracic respiratory organ of pupa.
Fig. 6. *Limnobia triocellata,* mandible of larva.
Fig. 7. *Limnophila luteipennis,* head of larva, dorsal view.
Fig. 8. *Limnophila tenuipes,* apical segment of male pupa.
Fig. 9. The same, apical segment of female pupa.
Fig. 10. *Limnobia triocellata,* apical segment of larva, lateral view.
Fig. 11. *Limnobia immatura,* side view of pupal exuvium.
Fig. 12. The same, dorsal view of apical segment of pupal exuvium.
Fig. 13. *Limnobia triocellata,* larva, lateral view.
Fig. 14. *Limnobia immatura,* thoracic respiratory organ of pupa.
Fig. 15. *Limnophila luteipennis,* mandible of larva.
Fig. 16. *Limnobia triocellata,* head of larva, dorsal view.
Fig. 17. The same, head of larva, ventral view.
Fig. 18. *Limnophila luteipennis,* thoracic respiratory organ of pupa.

PLATE XXXIII

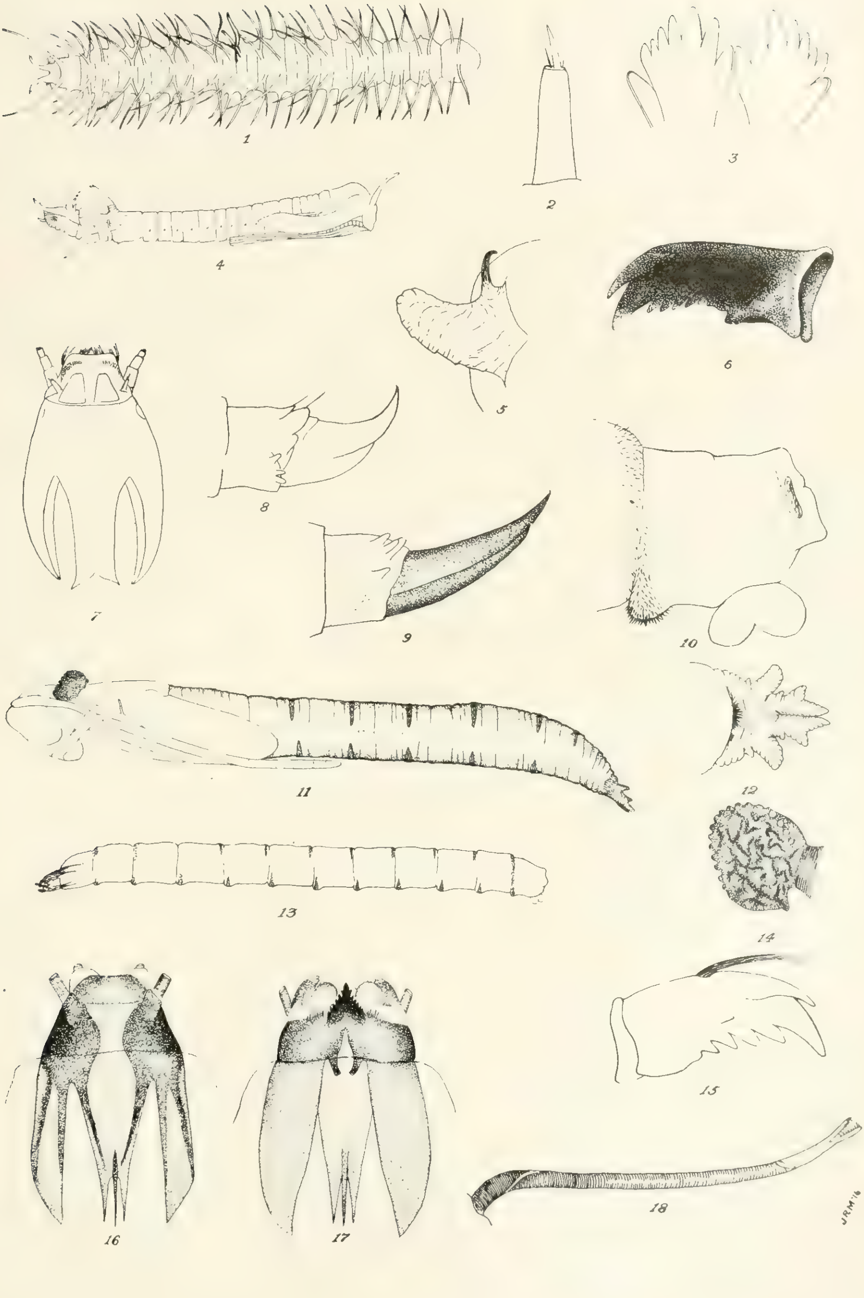


Plate XXXIV

Larvae and Pupae of Limnobiidae

Fig. 1. *Limnobia immatura,* face of pupa, seen from above.
Fig. 2. *Limnobia triocellata,* face of pupa, seen from above.
Fig. 3. The same, apical segment of pupa, dorsal view.
Fig. 4. The same, apical segment of pupa, lateral view.
Fig. 5. *Dicranota* sp., maxillary palpus of larva.
Fig. 6. The same, antenna of larva.
Fig. 7. The same, larva, lateral view.
Fig. 8. *Genus incertus* 2, larva, lateral view.
Fig. 9. *Dicranota* sp., head of larva, dorsal view.
Fig. 10. *Gnophomyia tristissima,* head of larva, dorsal view.
Fig. 11. *Helobia punctipennis,* mandible of larva.
Fig. 12. *Penthoptera* sp., head of larva, dorsal view.
Fig. 13. The same, apical segment of larva, dorsal view.
Fig. 14. The same, larva, lateral view.
Fig. 15. *Genus incertus,* 2, apical segment of larva, dorsal view.
Fig. 16. *Gnophomyia tristissima,* apical segment of larva, caudal view.
Fig. 17. *Helobia punctipennis,* apical segment of larva, caudal view.
Fig. 18. The same, head of larva, dorsal view.
Fig. 19. *Genus incertus* 3, head of larva, dorsal view.

PLATE XXXIV

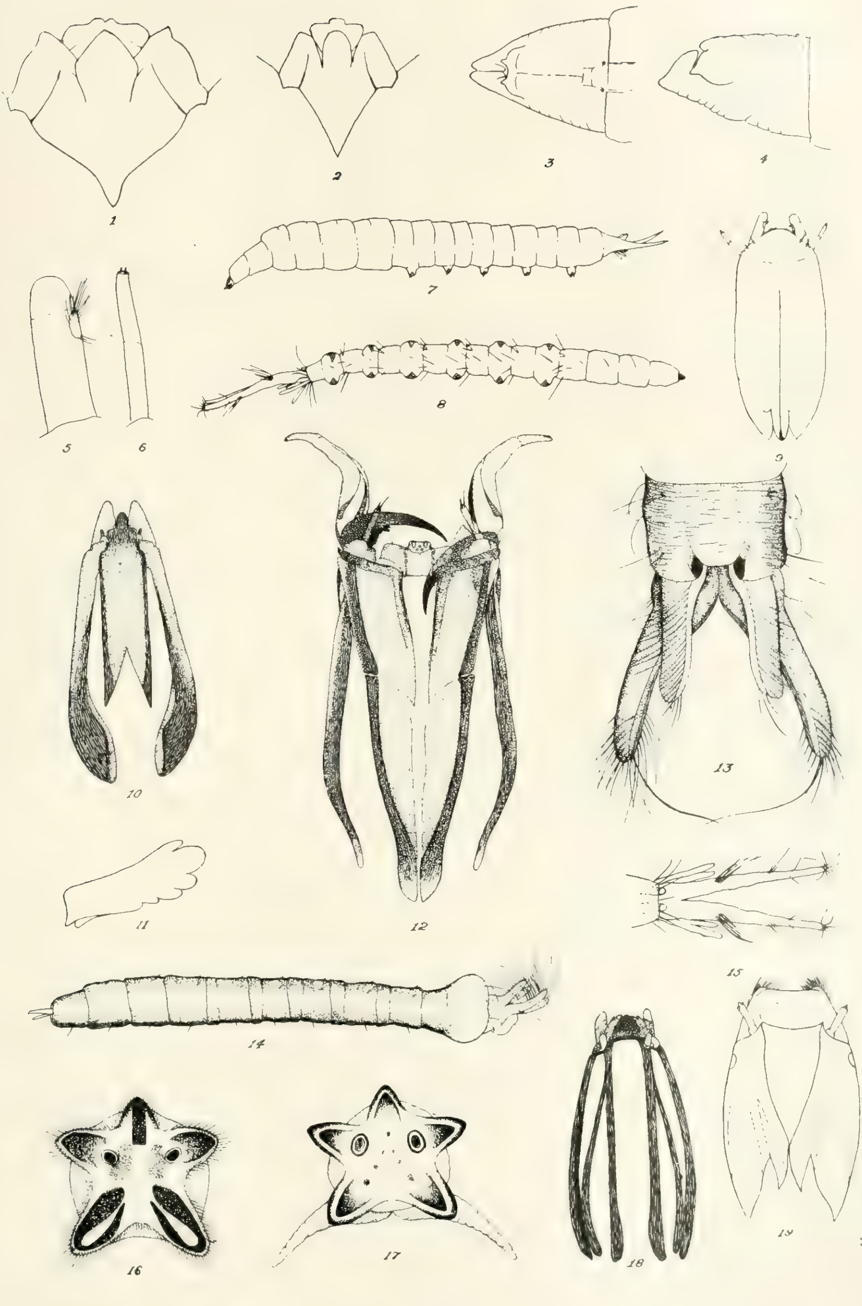


Plate XXXV

Larvae and Pupae of Limnobiidae and Ptychopteridae

Fig. 1. *Genus incertus* 2, head of larva, dorsal view.
Fig. 2. *Epiphragma fascipennis*, larva, lateral view. (After Needham.)
Fig. 3. The same, apical segment of larva, dorsal view. (After Needham.)
Fig. 4. *Genus incertus* 2, head of larva, ventral view.
Fig. 5. *Bittacomorpha clavipes*, head of larva, dorsal view of one half.
Fig. 6. The same, head and thorax of pupa, ventral view.
Fig. 7. *Ptychoptera* sp.?, head of larva, dorsal view of one half: *a*, antenna; *e*, eye; *l*, labrum; *m*, mandible.
Fig. 8. *Bittacomorpha clavipes*, head of larva, ventral view of one half.
Fig. 9. *Epiphragma fascipennis*, pupa, ventral view. (After Needham.)
Fig. 10. *Ptychoptera* sp., head of larva, ventral view of one half: *e*, epipharynx; *m*, mandible; *a*, antenna; *mp*, maxillary palpus; *l*, labium.
Fig. 11. *Genus incertus* 1, larva, lateral view.
Fig. 12. *Ptychoptera* sp.?, larva, lateral view.
Fig. 13. *Genus incertus* 1, apical segment of larva, dorsal view.
Fig. 14. The same, locomotor organ of larva.
Fig. 15. *Bittacomorpha clavipes*, mandible of larva.
Fig. 16. *Genus incertus* 1, ventral view of head of larva.

Plate XXXV

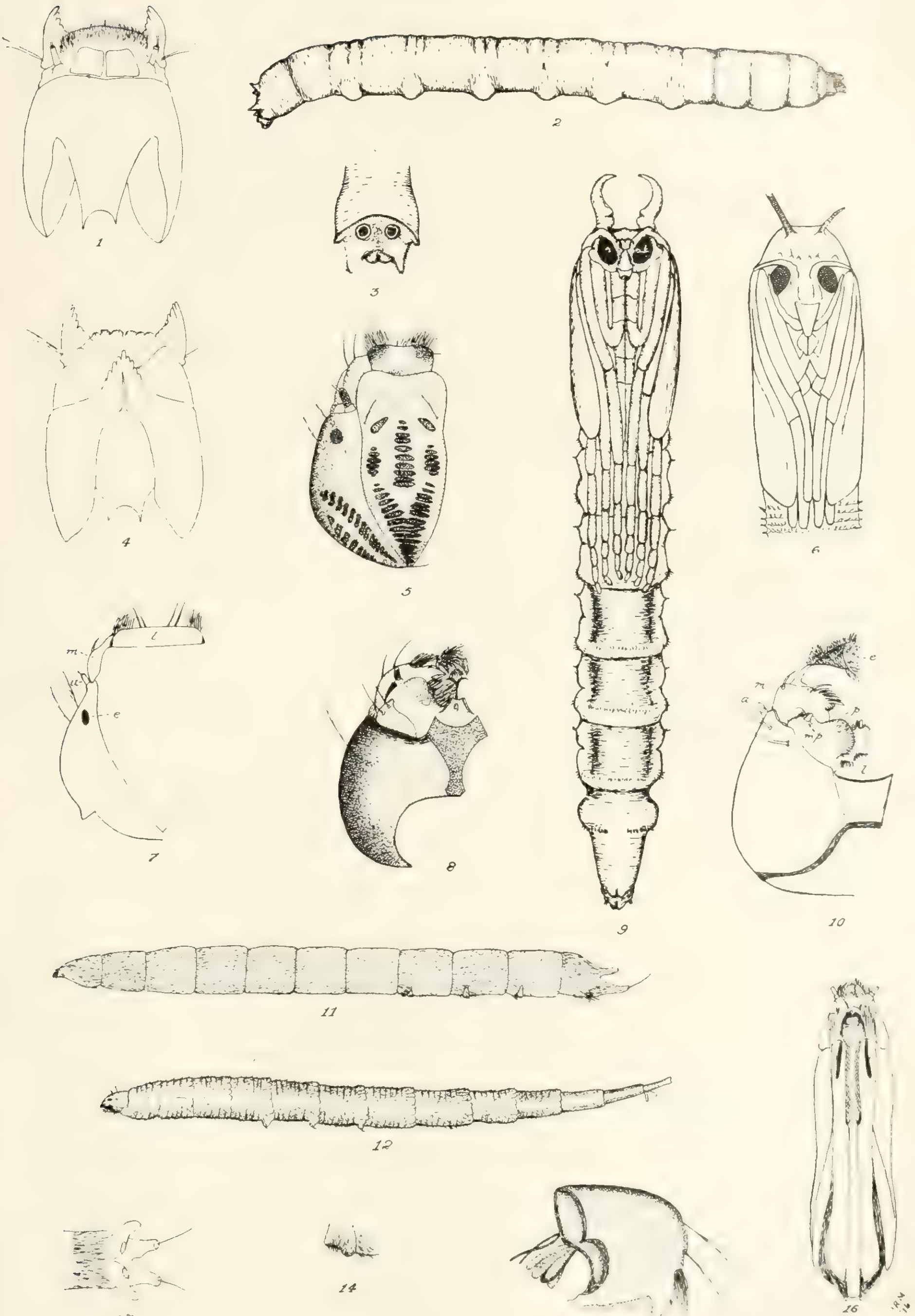
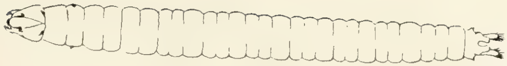


Plate XXXVI

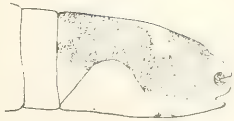
Larva of Limnobiidae and Larvae and Pupae of Rhyphidae

Fig. 1. *Trichocera* sp.?, larva, dorsal view.
Fig. 2. *Rhyphus punctatus*, apical segment of larva, lateral view.
Fig. 3. *Mycetobia divergens*, larva, lateral view.
Fig. 4. *Rhyphus punctatus*, head of larva, dorsal view.
Fig. 5. The same, mandible of larva.
Fig. 6. *Mycetobia divergens*, head, thorax, and base of abdomen of pupa, ventral view.
Fig. 7. The same, head and thorax of pupa, dorsal view.
Fig. 8. The same, head, thorax, and base of abdomen of pupa, lateral view.
Fig. 9. *Rhyphus punctatus*, head, thorax, and base of abdomen of pupa, lateral view.
Fig. 10. *Trichocera* sp.?, labium, maxilla, and mandible of larva, ventral view.
Fig. 11. *Mycetobia divergens*, labium, maxilla, and mandible of larva, ventral view.
Fig. 12. *Rhyphus punctatus*, labium and maxillae of larva, ventral view.

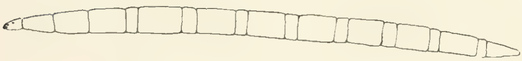
Plate XXXVI



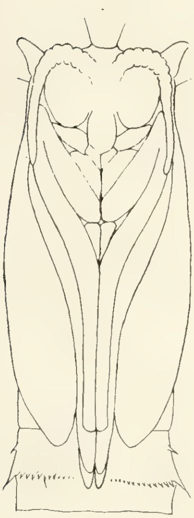
1



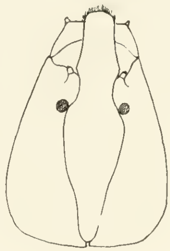
2



3

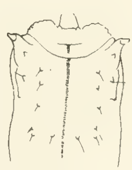


6

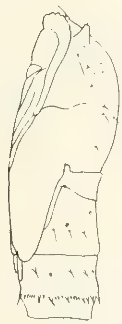


4

5



7



8

9

10

11

12

Plate XXXVII

Larvae and Pupae of Mycetophilidae

Fig. 1. *Leia oblectabilis*, head of larva, dorsal view (punctures not drawn).
Fig. 2. *Exechia nativa*, locomotor spinules of larva.
Fig. 3. The same, larva, lateral view.
Fig. 4. The same, prothoracic spiracle of larva.
Fig. 5. *Leia oblectabilis*, pupa, lateral view.
Fig. 6. *Exechia nativa*, mandible of larva.
Fig. 7. The same, head of larva, dorsal view.
Fig. 8. *Leia oblectabilis*, hypopharynx of larva.
Fig. 9. *Exechia nativa*, maxilla of larva; *p*, maxillary palpus.
Fig. 10. *Leia oblectabilis*, mandible of larva.
Fig. 11. *Exechia nativa*, hypopharynx of larva.
Fig. 12. The same, pupa, lateral view; *a*, larval head and skin.
Fig. 13. *Leia oblectabilis*, maxilla of larva; *p*, maxillary palpus.
Fig. 14. The same, head of larva, ventral view: *o*, eye (=pellucid spot ventrad of antenna); *m*, mandible; *mx*, maxilla; *h*, hypopharynx.
Fig. 15. *Exechia nativa*, illustrating effect of parasitism upon pupa; *a*, larval head and skin.
Fig. 16. *Polylepta leptogaster*, mandible of larva. (After Schmitz.)
Fig. 17. *Mycoma brevivittata*, mandible of larva.
Fig. 18. The same, pupa, lateral view.

PLATE XXXVII

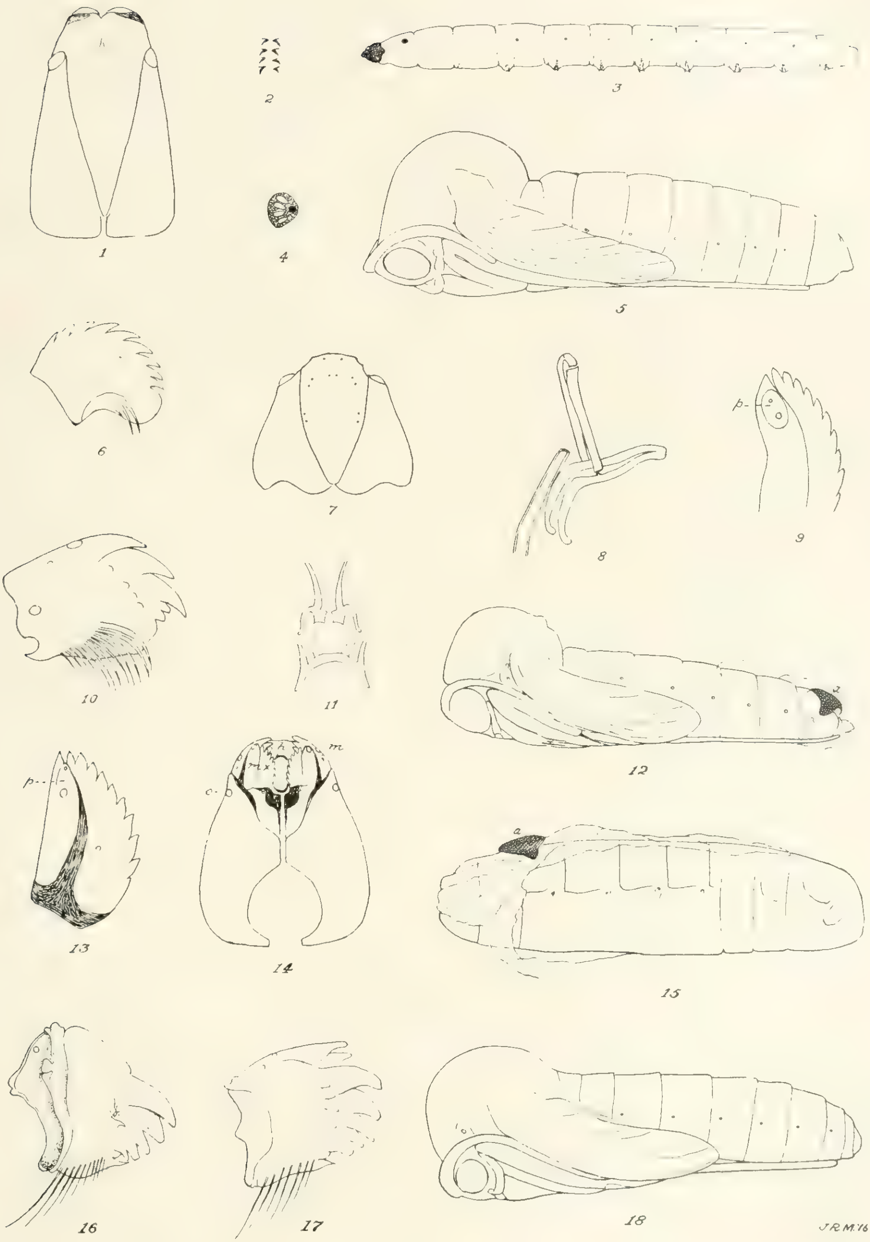


Plate XXXVIII

Larvae and Pupae of Mycetophilidae, Sciaridae, and Platyuridae

Fig. 1. *Mycoma brevivittata*, ventral aspect of head and thorax of pupa: *A*, antenna; *P*, palpus; *1*, coxa, *2*, femur, *3*, tibia, *4*, tarsus of fore leg; *1a*, coxa of mid leg; *4a*, tarsus of mid leg; *W*, wing.

Fig. 2. *Sciara prolifica*, head of larva, ventral view: *la*, labium; *a*, antenna; *mx*, maxilla; *mp*, maxillary palpus; *m*, mandibles; *lb*, labrum.

Fig. 3. *Polylepta leptogaster*, head of larva, ventral view: parts figured and lettering as for Figure 2. (After Schmitz.)

Fig. 4. *Mycoma brevivittata*, head of larva, ventral view: parts figured and lettering as for Figure 2.

Fig. 5. *Sciara prolifica*, ventral aspect of head and thorax of pupa: parts figured and lettering as for Figure 1.

Fig. 6. *Sciara* sp.?, head of larva, dorsal view.

Fig. 7. *Sciara prolifica*, pupa, lateral view.

Fig. 8. *Ceroplatus* sp.?, maxilla of larva.

Fig. 9. *Sciara* sp.?, dorsal sclerite of head of larva, and the hypopharynx.

Fig. 10. *Ceroplatus* sp.?, head of larva, dorsal view.

Fig. 11. The same, head of larva, ventral view: *a*, antenna; *lb*, labrum; *m*, mandible; *mx*, maxilla; *la*, labium.

Fig. 12. The same, mandible of larva.

Fig. 13. The same, apical segment of larva, dorsal view, showing tracheation.

Fig. 14. *Sciara* sp.?, mandible of larva.

Fig. 15. *Ceroplatus* sp.?, head of larva, front view: parts figured and lettering—with the addition of *o*, eye—as for Figure 1.

Fig. 16. The same, pupa, lateral view.

PLATE XXXVIII

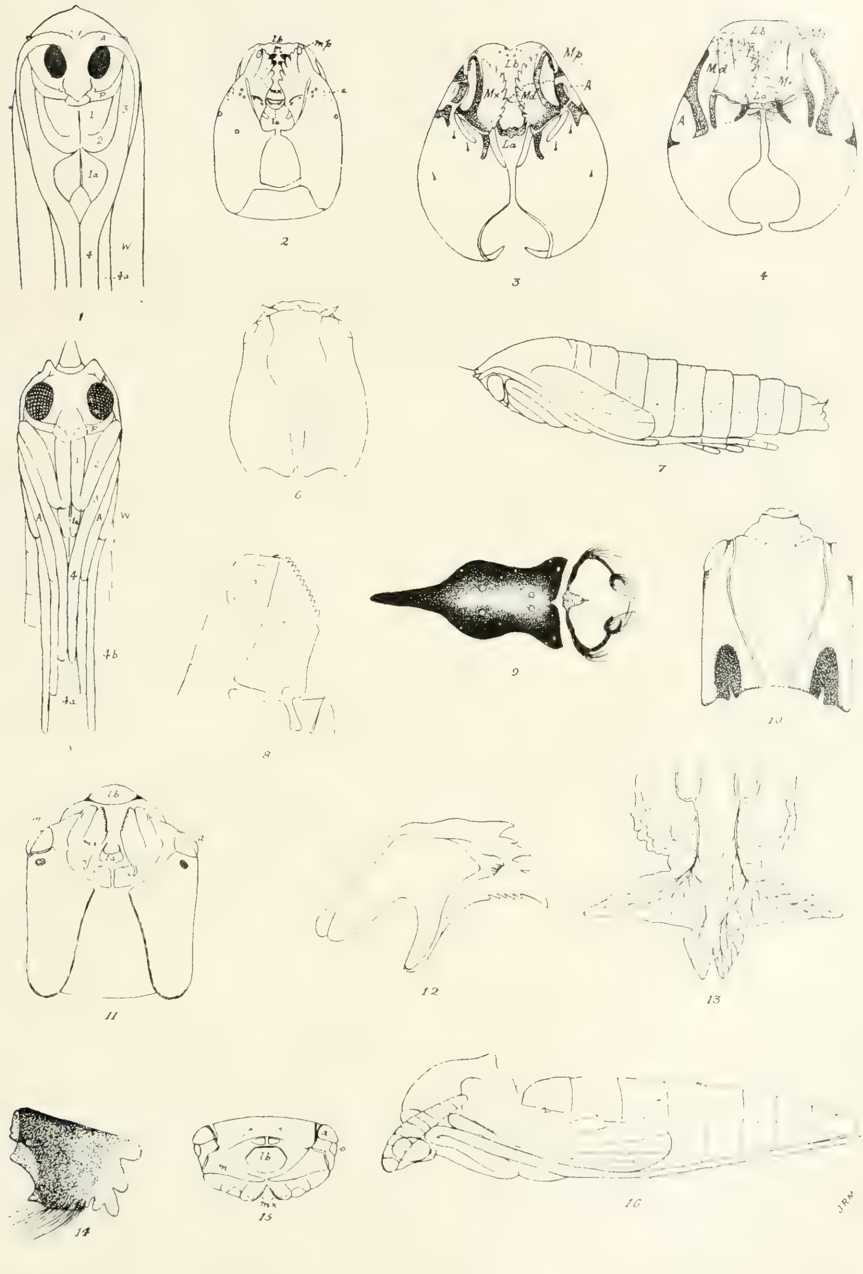


Plate XXXIX

Larvae and Pupae of Psychodidae

Fig. 1. *Psychoda minuta*, ventral view of apical segment of pupa.
Fig. 2. *Psychoda superba*, lateral view of apical segment of pupa.
Fig. 3. *Psychoda cinerea*, lateral view of apical segment of pupa.
Fig. 4. *Psychoda superba*, apical armature of second dorsal abdominal segment of pupa.
Fig. 5. *Psychoda minuta*, thoracic respiratory organ of pupa.
Fig. 6. *Psychoda superba*, thoracic respiratory organ of pupa: (*a*, small opening in surface; *b*, portion showing the surface reticulation.
Fig. 7. *Psychoda minuta*, dorsal view of larva.
Fig. 8. *Psychoda superba*, plates of second dorsal abdominal segment.
Fig. 9. *Psychoda minuta*, lateral view of apical segment of larva.
Fig. 10. *Psychoda superba*, ventral view of pupa.
Fig. 11. *Psychoda cinerea*, dorsal view of larva.
Fig. 12. *Psychoda superba*, antenna of larva.
Fig. 13. The same, dorsal view of larva.
Fig. 14. *Psychoda* sp.?, dorsal view of larva.
Fig. 15. *Psychoda superba*, lateral view of apical segment of larva.
Fig. 16. *Psychoda minuta*, head of pupa: *a*, antenna; *c*, eye; *c*, clypeus; *p*, palpi; *t*, tibia.
Fig. 17. The same, dorsal view of second abdominal segment of pupa.
Fig. 18. The same, ventral view of third abdominal segment of pupa.

PLATE XXXIX

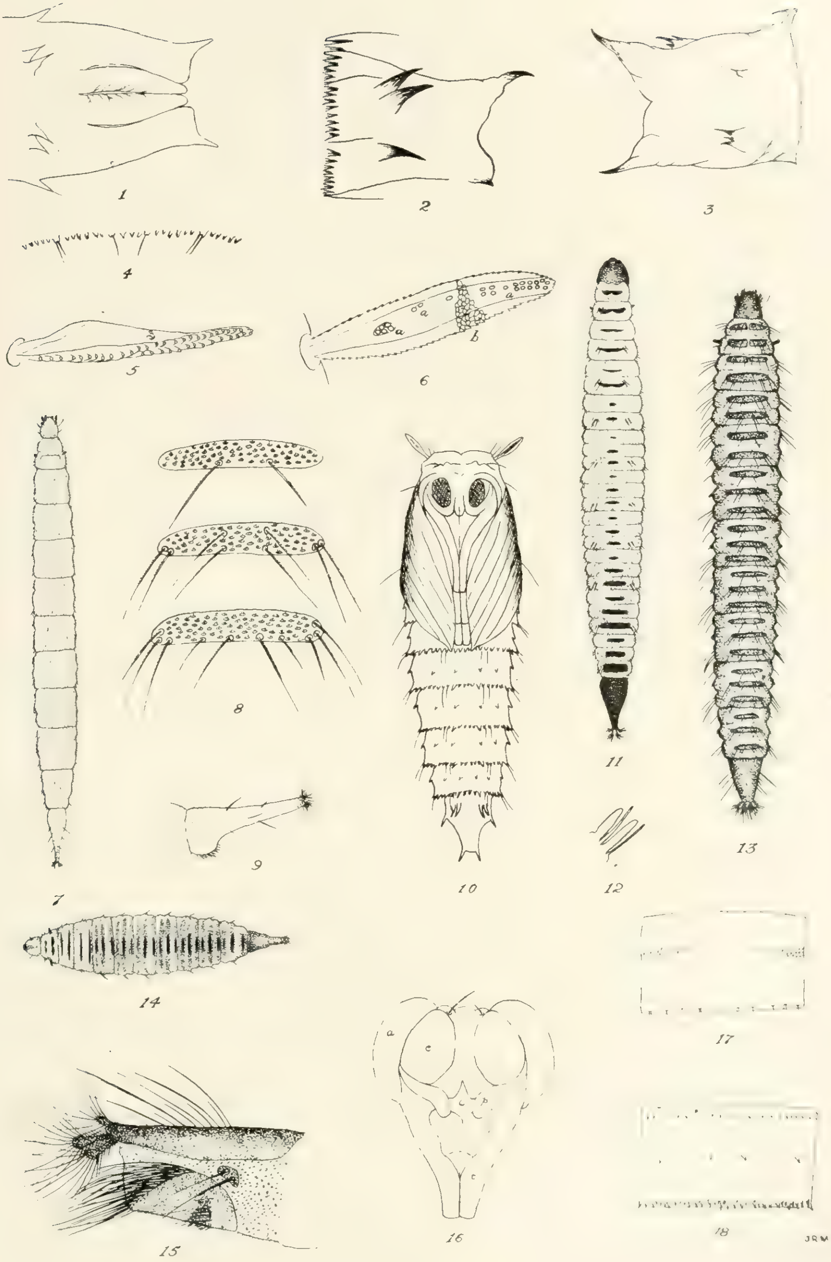


Plate XL

Larvae and Pupae of Blepharoceridae, Culicidae, and Dixidae

Fig. 1. *Bibiocephala* sp.?, larva, dorsal view.
Fig. 2. The same, pupa, ventral view.
Fig. 3. *Culex restuans*, larva, dorsal view.
Fig. 4. *Bibiocephala* sp.?, pupa, lateral view.
Fig. 5. *Dixa* sp.?, larva, lateral view.
Fig. 6. *Bibiocephala* sp.?, thoracic respiratory organ of pupa.
Fig. 7. *Dixa* sp.?, pupa, lateral view.
Fig. 8. *Culex restuans*, pupa, lateral view.

PLATE XL

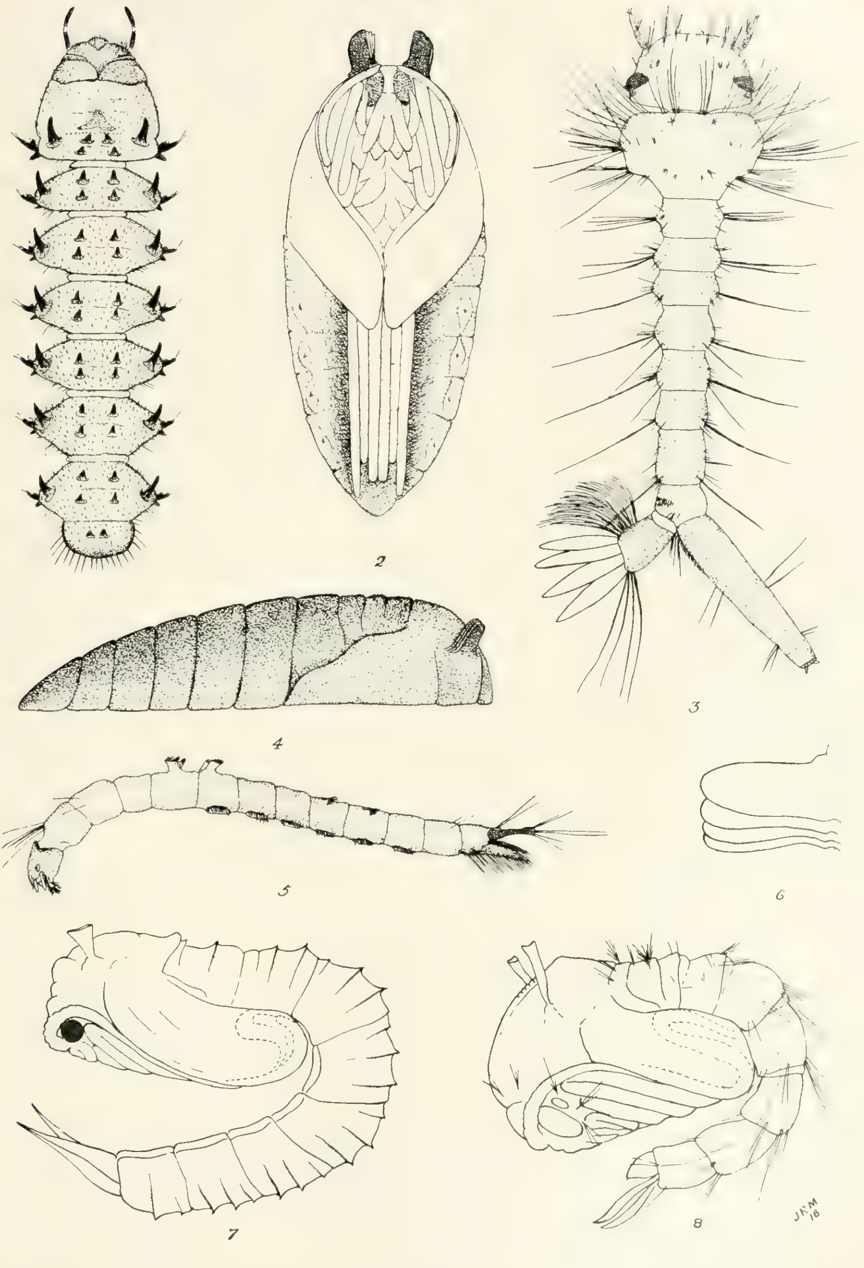


Plate XLI

Larvae and Pupae of Culicidae, Dixidae, Ceratopogonidae, and Chironomidae

Fig. 1. *Sayomyia americana,* head of larva, lateral view.
Fig. 2. The same, larva, lateral view.
Fig. 3. *Dixa* sp.?, labium of larva.
Fig. 4. *Camptocladius byssinus,* antenna of larva.
Fig. 5. *Dixa* sp.?, head of larva, dorsal view: *A*, antenna; *B*, labrum; *C*, epipharynx; *D*, maxillary palpus; *E*, mandible; *F*, maxillary lobe or mouth-brush.
Fig. 6. *Forcipomyia cilipes,* dorso-lateral bristle of larva.
Fig. 7. *Ceratopogon fusculus,* dorsal abdominal bristle of pupa.
Fig. 8. *Forcipomyia specularis,* dorsal bristle of larva, side view.
Fig. 9. The same, dorsal bristle of larva, front view.
Fig. 10. *Forcipomyia cilipes,* dorsal bristle of larva, front view.
Fig. 11. *Forcipomyia pergandei?*, antenna of larva.
Fig. 12. *Camptocladius byssinus,* apical segment of larva, ventral view.
Fig. 13. *Palpomyia longipennis,* mandible of larva.
Fig. 14. *Forcipomyia specularis,* mandible of larva.
Fig. 15. The same, head of larva, lateral view.
Fig. 16. *Camptocladius byssinus,* larva, lateral view.
Fig. 17. The same, prothoracic pseudopod of larva, lateral view.

Plate XLI

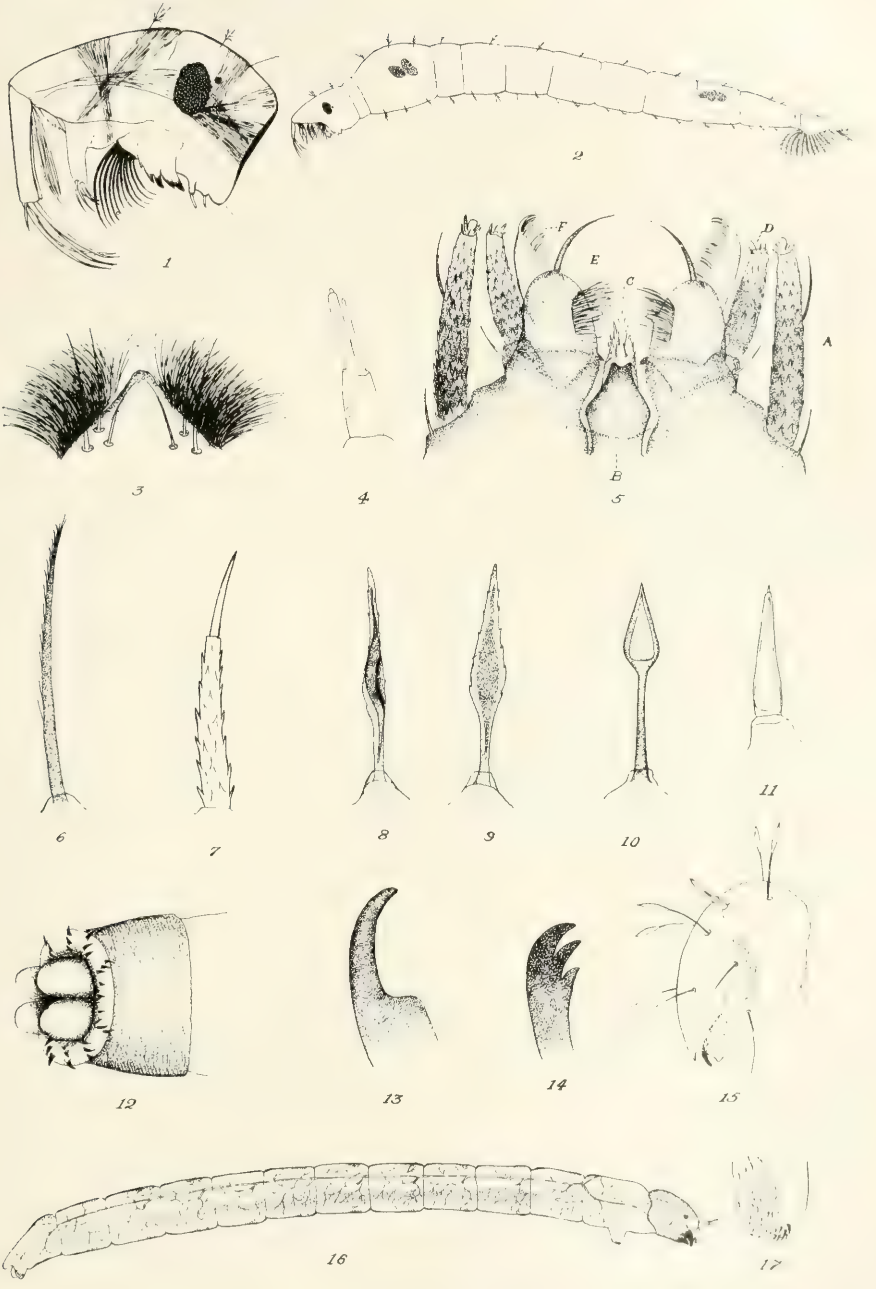
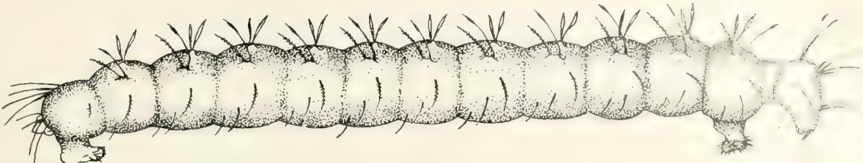


Plate XLII

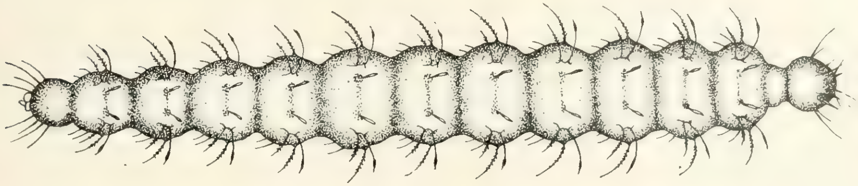
Larvae and Pupae of Ceratopogonidae

Fig. 1. *Forcipomyia specularis,* larva, lateral view.
Fig. 2. The same, larva, dorsal view.
Fig. 3. *Forcipomyia cilipes,* larva, lateral view.
Fig. 4. *Ceratopogon fusculus,* larva, dorsal view.
Fig. 5. *Palpomyia?* sp.?, pupa, dorsal view.
Fig. 6. *Palpomyia longipennis,* larva, lateral view.

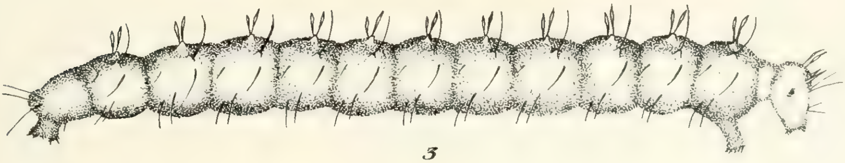
Plate XLII



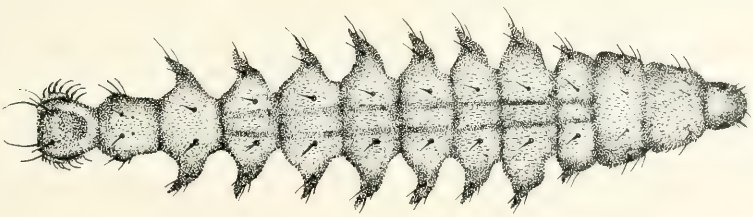
1



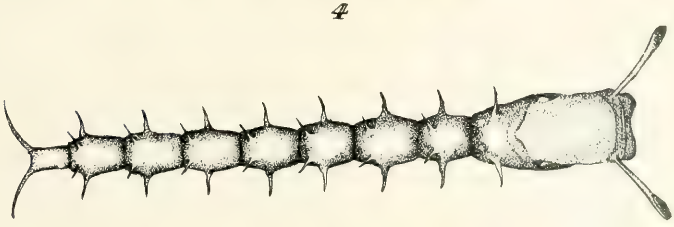
2



3



4



5

J R Malloch 14

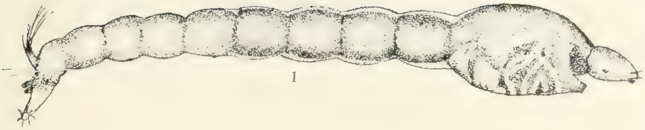
6

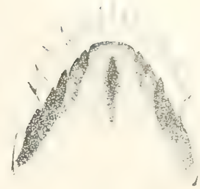
Plate XLIII

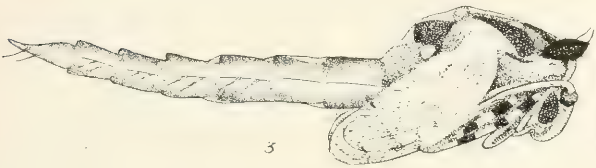
Larvae and Pupae of Chironomidae

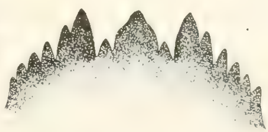
Fig. 1. *Tanypus monilis,* larva, lateral view, showing development of imago before pupation.
Fig. 2. *Orthocladius* sp.?, labium of larva.
Fig. 3. *Tanypus illinoensis,* pupa, lateral view.
Fig. 4. *Chironomus tentans,* labium of larva.
Fig. 5. The same, larva, lateral view.
Fig. 6. *Cricotopus trifasciatus,* pupa, lateral view.
Fig. 7. *Tanypus pilosellus,* head of larva, ventral view.
Fig. 8. *Protenthes culiciformis,* head of larva, ventral view.
Fig. 9. *Tanytarsus* sp.?, larval case.
Fig. 10. *Protenthes punctipennis,* respiratory organ of pupa.

PLATE XLIII


1

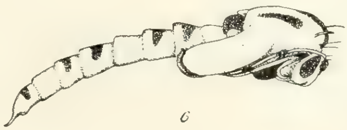

2

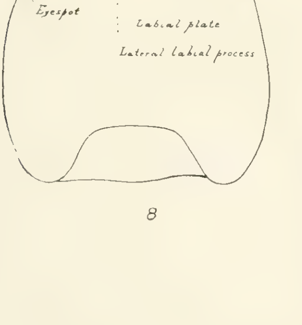

3


4


5


7


6



8


9


10

Plate XLIV

Larvae and Pupae of Cecidomyiidae and Bibionidae

Fig. 1. *Retinodiplosis pini-inops,* larva, lateral view.
Fig. 2. *Rhabdophaga podagrae,* apices of legs and wings, showing their relative positions.
Fig. 3. *Monardia* sp.?, head and first two thoracic segments, ventral view, showing spatula.
Fig. 4. *Rhabdophaga* sp., head of pupa, lateral view.
Fig. 5. The same, head of pupa, dorsal view.
Fig. 6. *Retinodiplosis pini-inops,* head of larva, showing details of dorsum and venter.
Fig. 7. *Monardia* sp.?, pupa, lateral view.
Fig. 8. *Rhabdophaga podagrae,* head of pupa, dorsal view.
Fig. 9. *Retinodiplosis pini-inops,* anal spiracle of larva.
Fig. 10. *Bibio albipennis,* larva, lateral view.
Fig. 11. The same, pupa, ventral view.
Fig. 12. *Retinodiplosis pini-inops,* spatula of larva.

PLATE XLIV

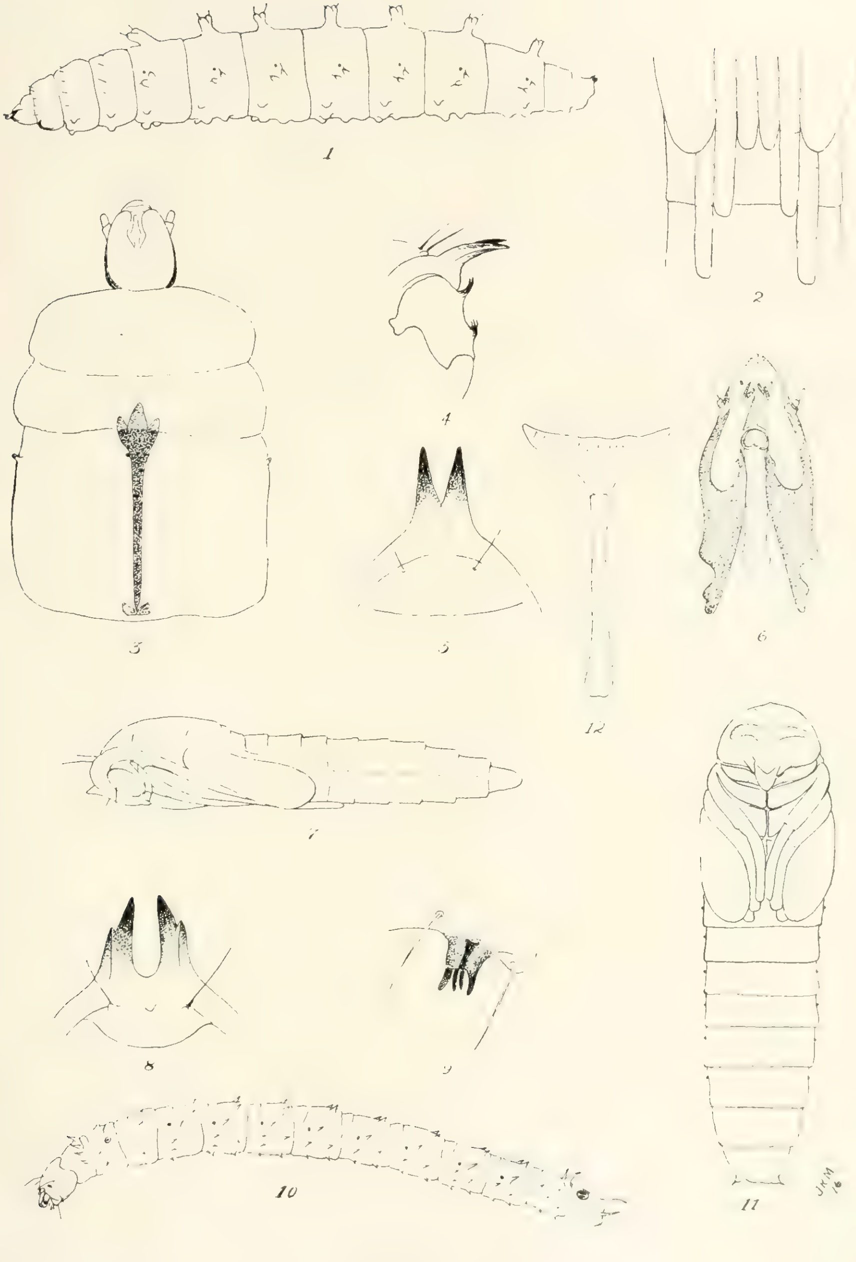


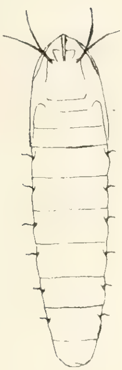
Plate XLV

Larvae and Pupae of Scatopsidae, Simuliidae, and Limnobiidae

Fig. 1. *Scatopse atrata*, larva, dorsal view.
Fig. 2. The same, pupa, dorsal view.
Fig. 3. The same, pupa, lateral view of head, thorax, and base of abdomen.
Fig. 4. The same, pupa, ventral view of head, thorax, and base of abdomen.
Fig. 5. The same, thoracic respiratory organ of pupa.
Fig. 6. *Trichocera* sp.?, ventral view of apical segment of larva.
Fig. 7. The same, lateral view of apical segment of larva.
Fig. 8. *Scatopse atrata*, antenna of larva.
Fig. 9. *Simulium vittatum*, pupa, ventral view.

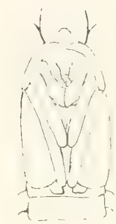
PLATE XLV

1



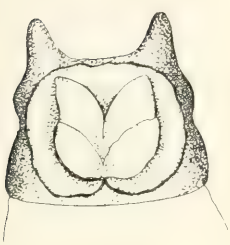
2

3



4

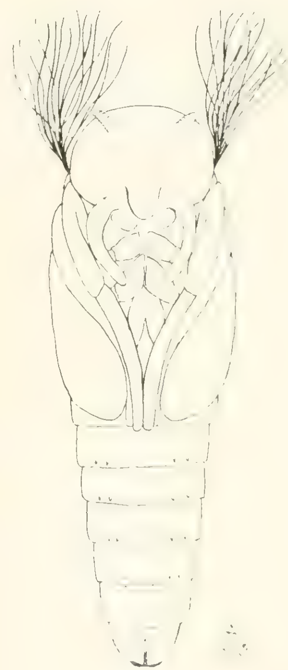
5



6

7

8



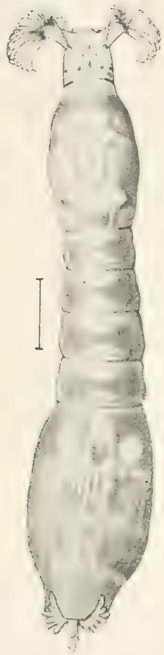
9

Plate XLVI

Stages of Simuliidae

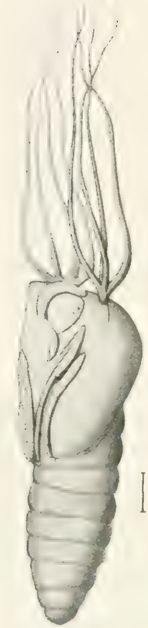
Fig. 1. *Simulium johannseni,* larva, dorsal view.
Fig. 2. *Simulium piscicidium,* pupa, lateral view.
Fig. 3. *Simulium johannseni,* pupa, lateral view.
Fig. 4. *Simulium venustum,* pupae in their cocoons.
Fig. 5. The same, head and thorax of male imago.

Plate XLVI

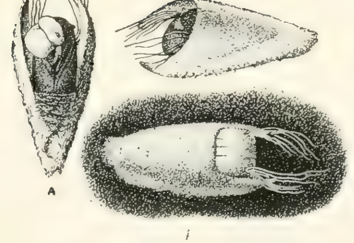


1

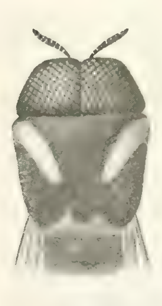
2



3



4



5

Plate XLVII

Larvae and Eggs of Stratiomyiidae

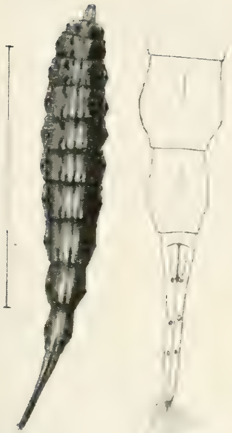
Fig. 1. *Stratiomyia norma,* larva, dorsal view, and a more enlarged figure of apical 3 segments of same, ventral view.

Fig. 2. *Odontomyia vertebrata,* larva, dorsal view, etc.—as in Figure 1.

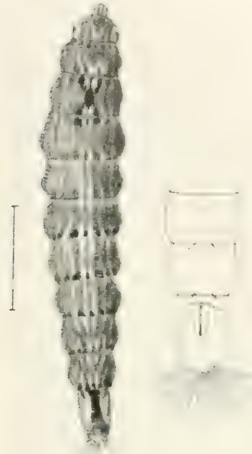
Fig. 3. *Odontomyia cincta,* larva, dorsal view, etc.—as in Figure 1.

Fig. 4. The same, egg-mass—with all but one layer of eggs removed—and a single egg much more enlarged.

Plate XLVII



1



2

3

4

Plate XLVIII

Larvae of Stratiomyiidae

Fig. 1. *Stratiomyia norma,* head of larva, ventral view: *a,* antenna; *p,* maxillary palpus; *e,* eye.

Fig. 2. The same, head of larva, dorsal view: *a,* antenna; *p,* maxillary palpus; *e,* eye.

Fig. 3. The same, maxilla of larva, *p,* palpus.

Fig. 4. *Xylomyia pallipes,* internal cephalic rods and maxilla.

Fig. 5. *Odontomyia cincta,* maxilla of larva, *p,* palpus; *a,* antenna.

Fig. 6. *Stratiomyia norma, m,* mandible of larva; *a,* antenna.

Fig. 7. *Odontomyia cincta, m,* mandible of larva; *a,* antenna.

Fig. 8. *Geosargus viridis,* head of larva, ventral view.

Fig. 9. *Xylomyia pallipes,* anterior spiracle of larva.

Fig. 10. *Hermetia illucens,* head of larva, dorsal view.

Fig. 11. The same, apical segment of larva, ventral view.

Fig. 12. *Geosargus viridis,* apical segment of larva, ventral view.

Fig. 13. *Hermetia illucens,* larva, dorsal view.

Fig. 14. *Xylomyia pallipes,* apical segment of larva, ventral view.

Fig. 15. The same, head of larva, dorsal view.

Fig. 16. *Geosargus viridis,* larva, dorsal view; *a,* lateral bristle; *b,* portion of surface showing shagreened markings.

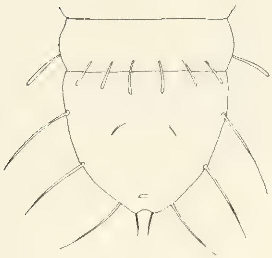
PLATE XLVIII

Plate XLIX

Larvae and Puparium of Stratiomyiidae

Fig. 1. *Genus incertus* 3, apical two segments of larva, dorsal view.
Fig. 2. *Microchrysa polita,* head of larva, dorsal view.
Fig. 3. The same, apical two segments of larva, dorsal view.
Fig. 4. *Eupachygaster henshawi,* head of larva, dorsal view.
Fig. 5. The same, head of larva, ventral view.
Fig. 6. *Neopachygaster maculicornis*, apical two segments of larva, dorsal view.
Fig. 7. *Xylomyia pallipes,* maxilla of larva.
Fig. 8. *Genus incertus* 2, apical two segments of larva, dorsal view.
Fig. 9. *Eupachygaster maculicornis,* empty puparium, dorsal view.
Fig. 10. *Xylomyia pallipes,* labium of larva.
Fig. 11. *Genus incertus* 1, larva, dorsal view.

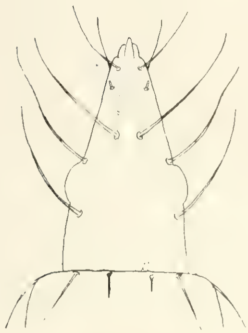
PLATE XLIX



1

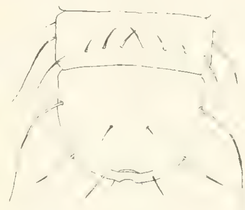
2

3



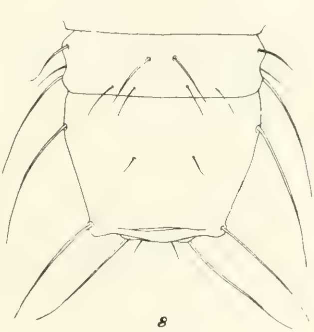
4

5

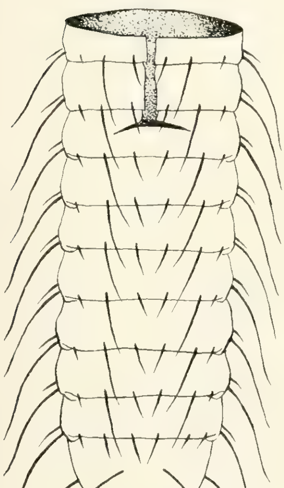


6

7

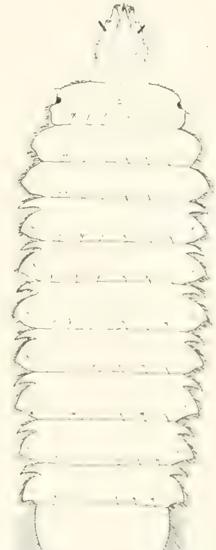


8



9

10



11

Plate L

Larvae and Pupae of Xylophagidae and Coenomyiidae

Fig. 1. *Xylophagus lugens,* pupa, lateral view.
Fig. 2. The same, apical segment of pupa, dorsal view.
Fig. 3. The same, head of larva, lateral view.
Fig. 4. *Coenomyia pallida,* head of larva, ventral view; and apex, lateral view, more enlarged.
Fig. 5. *Xylophagus lugens,* larva, dorsal view.
Fig. 6. The same, head of pupa, front view.
Fig. 7. *Xylophagus abdominalis,* head of pupa, front view.
Fig. 8. *Coenomyia pallida,* head of pupa, front view.
Fig. 9. The same, apical segment of larva, caudal view.
Fig. 10. *Xylophagus abdominalis,* prothorax of larva, lateral view.
Fig. 11. The same, head and thoracic segments of larva, dorsal view.
Fig. 12. *Coenomyia pallida,* apical three segments of pupa, lateral view.
Fig. 13. The same, apical segment of pupa, dorsal view.

PLATE L

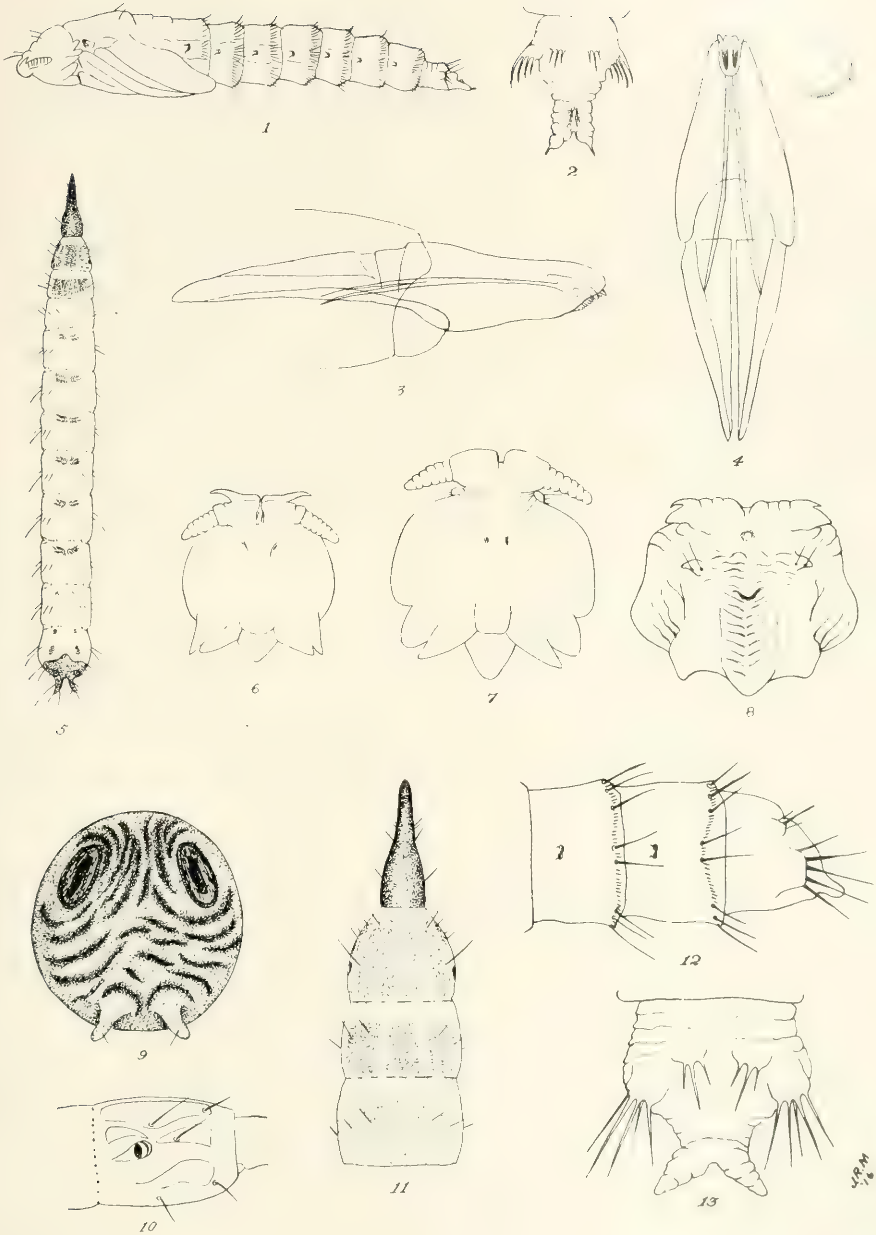


Plate LI

Larvae and Pupae of Tabanidae and Leptidae

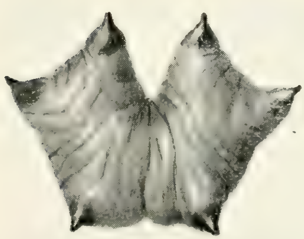
Fig. 1. *Chrysops vittatus,* larva, dorsal view.
Fig. 2. *Tabanus stygius,* larva, dorsal view.
Fig. 3. *Tabanus atratus,* larva, dorsal view.
Fig. 4. The same, apex of pupa, caudal view.
Fig. 5. *Tabanus lineola,* apex of pupa, caudal view.
Fig. 6. The same, pupa, dorsal view.

Plate LI

1

2

3



4

5

6

Plate LII

Larvae and Pupae of Tabanidae and Leptidae

Fig. 1. *Tabanus atratus,* head and prothorax of larva, lateral view.
Fig. 2. *Tabanus nigrescens,* thoracic respiratory organ of pupa, dorsal view; *s,* spiracle; *o,* mesal opening.
Fig. 3. *Chrysops vittatus,* thoracic respiratory organ of pupa, dorsal view; *s,* spiracle; *o,* mesal opening.
Fig. 4. *Tabanus stygius,* head of pupa, dorsal view.
Fig. 5. *Chrysops vittatus,* head of pupa, dorsal view.
Fig. 6. *Chrysopila ornata,* larva, lateral view.
Fig. 7. The same, pupa, lateral view.
Fig. 8. The same, head of larva, dorsal view.
Fig. 9. *Chrysopila* sp., apex of larva, lateral view.
Fig. 10. *Atherix* sp., larva, lateral view.
Fig. 11. *Chrysopila ornata,* apex of larva, lateral view.
Fig. 12. *Chrysopila quadrata,* apex of larva, lateral view.
Fig. 13. *Chrysopila ornata,* apex of pupa, caudal view.
Fig. 14. *Chrysopila quadrata,* apex of pupa, caudal view.

Plate LII

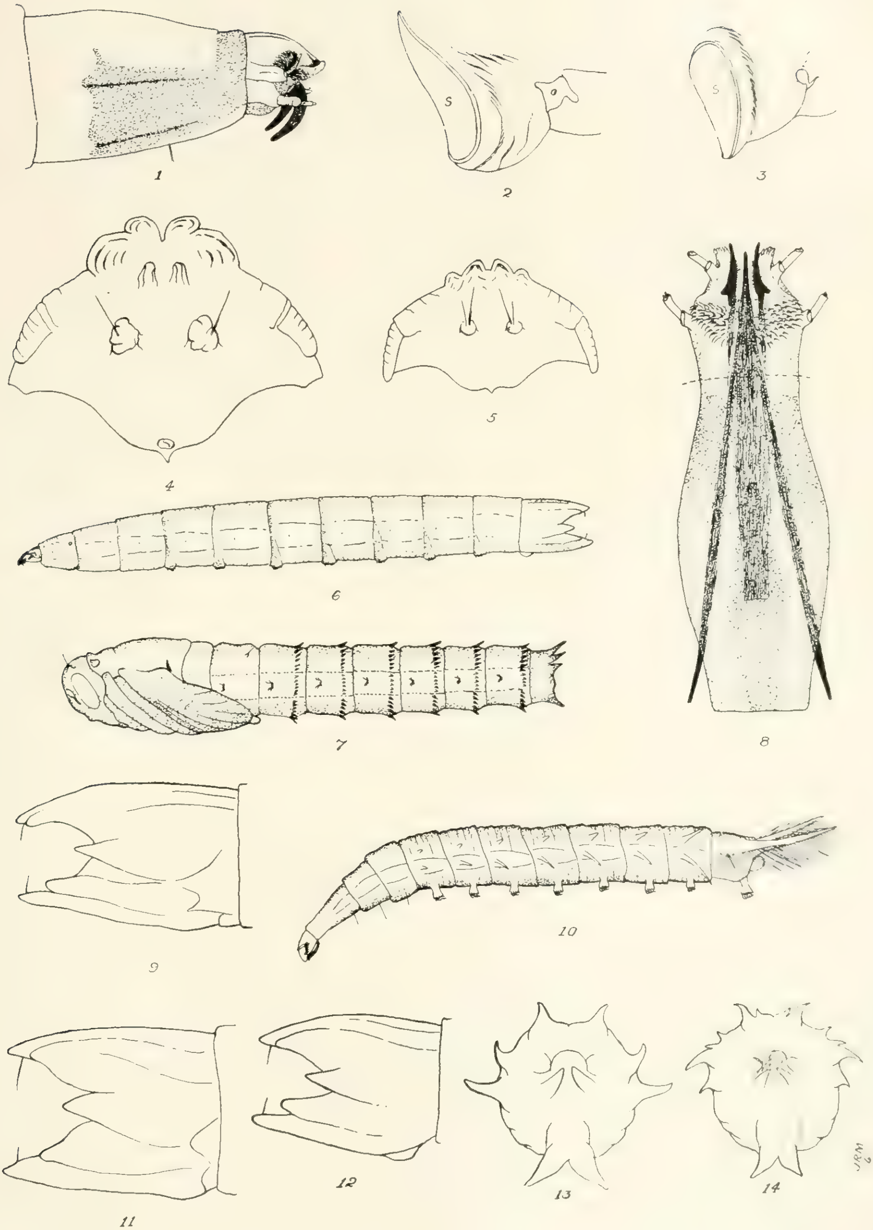


Plate LIII

Larvae and Pupae of Cyrtidae, Mydaidae, and Asilidae

Fig. 1. *Oncodes costatus,* pupa, lateral view.
Fig. 2. *Mydas clavatus,* apex of maxilla of larva, dorsal view.
Fig. 3. The same, pupa, lateral view.
Fig. 4. The same, larva, dorsal view.
Fig. 5. The same, head of larva, dorsal view.
Fig. 6. *Leptogaster flavipes,* pupa, lateral view.
Fig. 7. The same, head of larva, dorsal view.
Fig. 8. *Dasyllis* sp., pupa lateral view.

Plate LIII

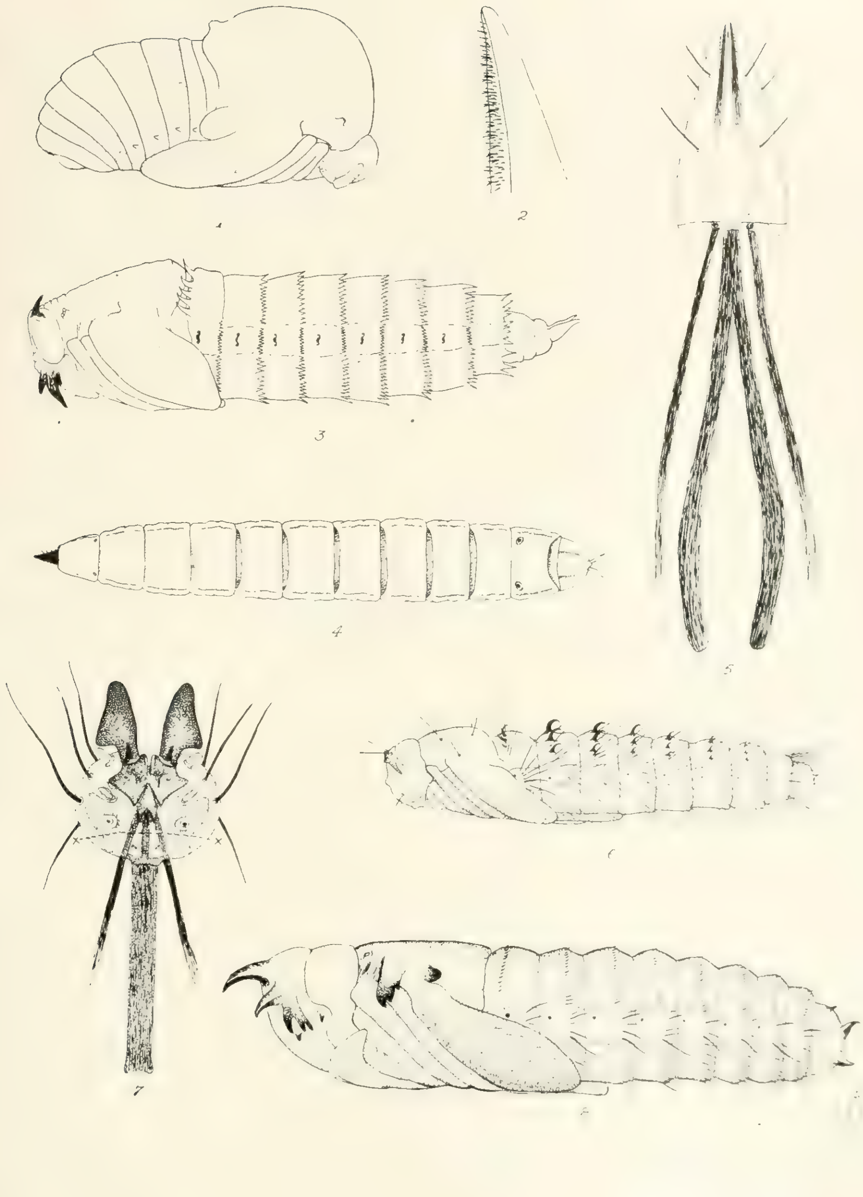


Plate LIV

Larvae and Pupae of Asilidae

Fig. 1. *Dasyllis* sp., head of pupa, front view.
Fig. 2. The same, apical segment of larva, latero-dorsal view.
Fig. 3. *Ceraturgus cruciatus*, apical segment of pupa, caudal view.
Fig. 4. The same, apical segment of pupa, dorsal view.
Fig. 5. (Number missing on plate.) *Promachus fitchii*, exposed portion of head of larva, dorsal view.
Fig. 6. *Ceraturgus cruciatus*, thoracic spiracle of pupa.
Fig. 7. *Deromyia discolor*, pupa, lateral view.
Fig. 8. *Ceraturgus cruciatus*, pupa, lateral view.
Fig. 9. *Promachus vertebratus*, larva, lateral view.
Fig. 10. *Asilus notatus*, head of larva, dorsal view; *a*, labrum.
Fig. 11. *Deromyia discolor*, exposed portion of head of larva, dorsal view.
Fig. 12. *Dasyllis* sp.?, exposed portion of head of larva, dorsal view: *l*, labrum; *m*, mandible; *mx*, maxilla; *mp*, maxillary palpus.
Fig. 13. *Promachus vertebratus*, exposed portion of head of larva, dorsal view.

PLATE LIV

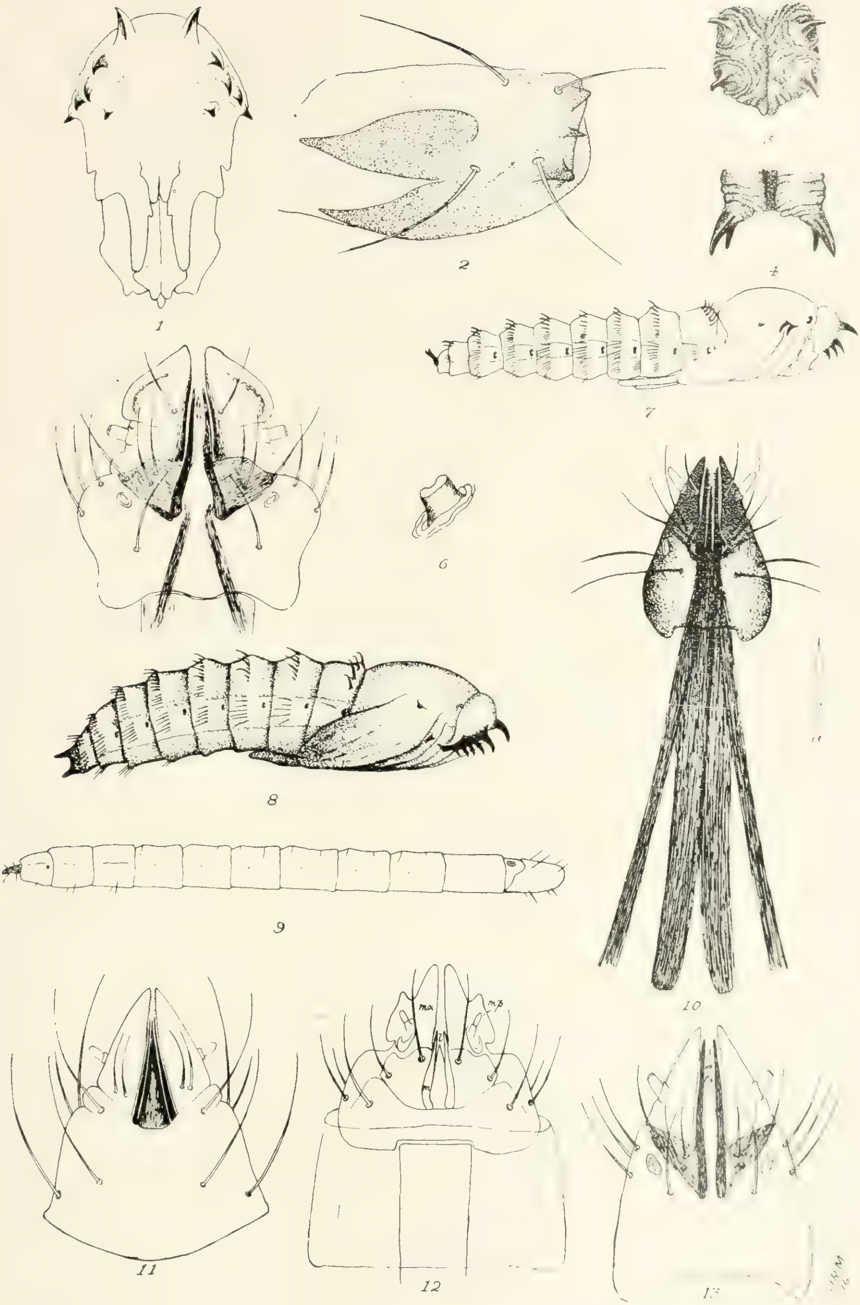


Plate LV

Larvae and Pupae of Asilidae

Fig. 1. *Ceraturgus cruciatus,* head of larva, dorsal view.
Fig. 2. *Asilus sericeus,* lateral cephalic thorns of pupa.
Fig. 3. The same, thorns above middle leg of pupa.
Fig. 4. *Erax maculatus,* lateral cephalic thorns of pupa.
Fig. 5. The same, thorns above middle leg of pupa.
Fig. 6. *Erax aestuans,* lateral cephalic thorns of pupa.
Fig. 7. The same, thorns above middle leg of pupa.
Fig. 8. *Erax maculatus,* apical segment of pupa, lateral view.
Fig. 9. *Erax aestuans,* apical segment of pupa, lateral view.
Fig. 10. *Asilus sericeus,* apical segment of pupa, lateral view.

PLATE LV

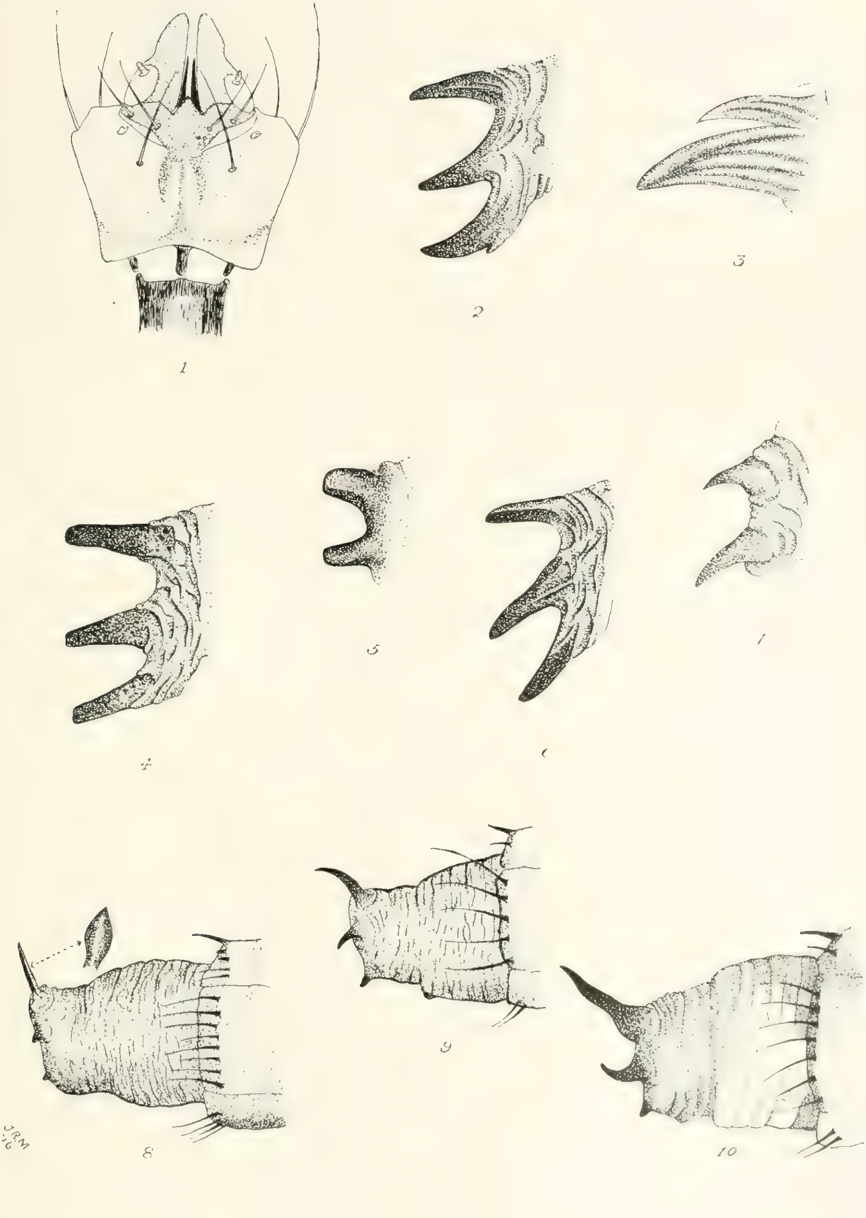


Plate LVI

Larvae and Pupae of Bombyliidae, Therevidae, and Scenopinidae

Fig. 1. *Sparnopolius fulvus*, larva, lateral view.
Fig. 2. The same, head of larva, lateral view.
Fig. 3. *Spogostylum albofasciatum*, pupa, lateral view.
Fig. 4. The same, apical segment of pupa, dorsal view.
Fig. 5. *Spogostylum simson*, apical segment of pupa, lateral view.
Fig. 6. The same, upper anterior and lateral cephalic thorns of one side of pupa.
Fig. 7. The same, terminal processes of apical segment of pupa, dorsal view.
Fig. 8. *Scenopinus fenestralis*, apical two segments of larva, lateral view.
Fig. 9. *Psilocephala haemorrhoidalis*, thoracic spiracle of larva.
Fig. 10. The same, larva, lateral view: *sp.*, spiracle; *1, 2, 3, 4, 5, 6*, basal six abdominal segments; *a*, apex, dorsal view.
Fig. 11. *Scenopinus fenestralis*, thoracic spiracle of larva.
Fig. 12. *Psilocephala haemorrhoidalis*, pupa, dorsal view.
Fig. 13. The same, apical segment of pupa, lateral view.

PLATE LVI

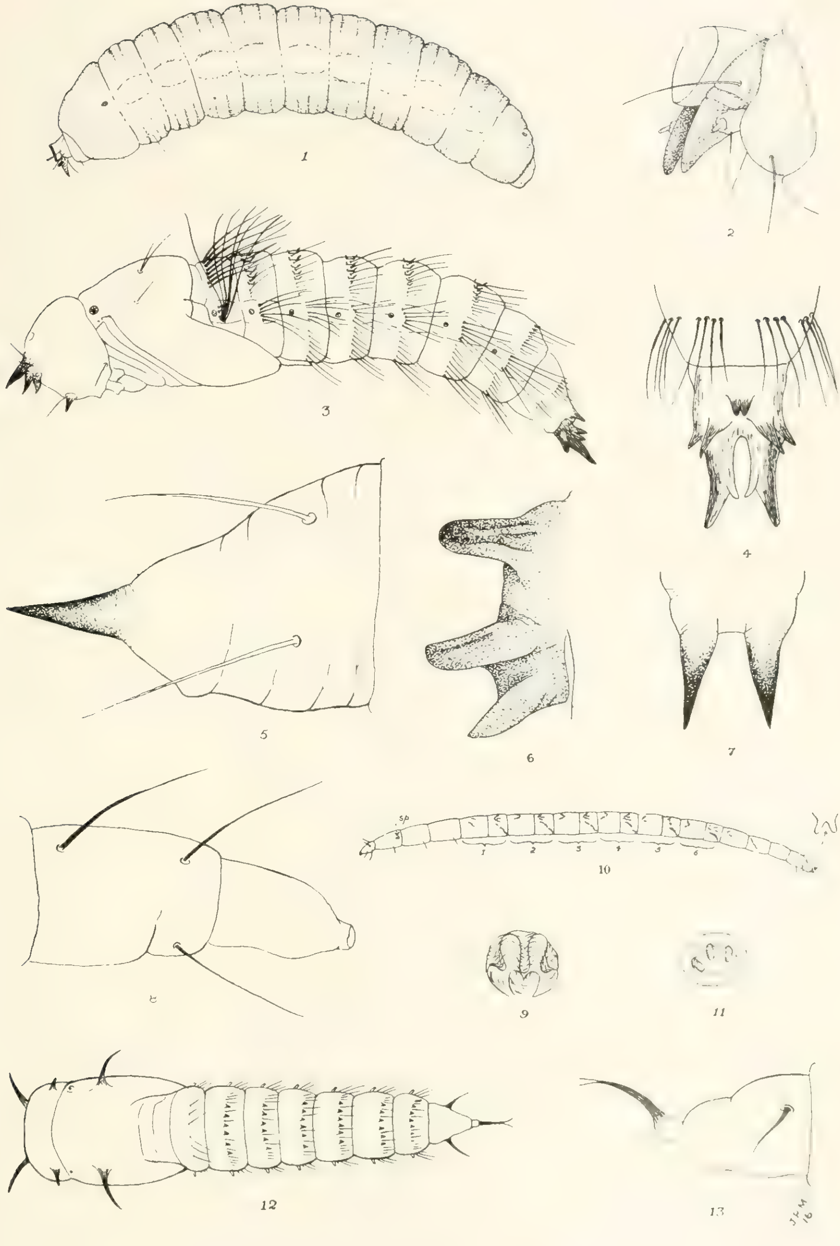


Plate LVII

Larvae of Therevidae and Dolichopodidae, and
Larvae and Pupae of Empididae

Fig. 1. *Psilocephala haemorrhoidalis*, head of larva, ventral view.
Fig. 2. *Scenopinus fenestralis*, head of larva, ventral view.
Fig. 3. *Dolichopus* sp. ?, larva, lateral view.
Fig. 4. *Rhamphomyia dimidiata*, head of larva, dorsal view: *a*, antenna; *l*, labrum; *md*, mandible; *m*, maxilla; *mp*, maxillary palpus.
Fig. 5. The same, pupa, lateral view.
Fig. 6. *Drapetis nigra*, head of larva, dorsal view.
Fig. 7. The same, pupa, lateral view.

Plate LVII

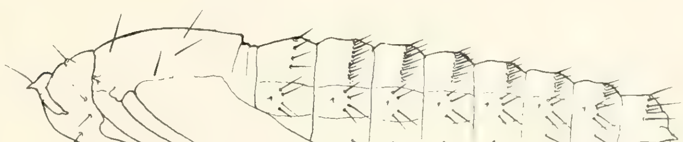
1

2

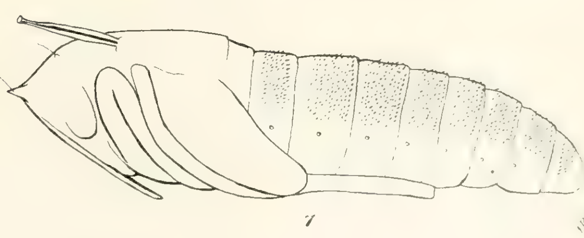
4

3

6



5



7

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. XII. | JUNE, 1917 | ARTICLE IV.

THE ZYGOPTERA, OR DAMSEL-FLIES, OF ILLINOIS

BY

PHILIP GARMAN, PH.D.

BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
DIRECTOR

VOL. XII. JUNE, 1917 ARTICLE IV.

THE ZYGOPTERA, OR DAMSEL-FLIES, OF ILLINOIS

BY

PHILIP GARMAN, PH.D.

CONTENTS

ARTICLE IV.—*The Zygoptera, or Damsel-flies, of Illinois.** BY PHILIP GARMAN, PH.D.

INTRODUCTION

The order Odonata includes all insects known as dragon-flies in the broad sense of the term. The adults are characterized by the possession of four membranous, net-veined wings which are of nearly equal size. The mouth-parts are fitted for biting and the metamorphosis is incomplete. The males are distinguished by accessory genitalia on the second and third abdominal sterna. The nymphs are aquatic, and are recognizable and separable from other aquatic forms by the large hinge-like labium which folds beneath the head. The order is subdivided into two suborders, the Anisoptera and the Zygoptera. The adults of the Anisoptera have large, broad wings, but little contracted at the base and with numerous cross-veins. The wings of the Zygoptera are usually narrowed at the base and possess fewer cross-veins. The Anisoptera usually rest with wings spread horizontally; the Zygoptera usually with wings held vertically. The nymphs of the suborders are easily separated by means of the respiratory apparatus, the Zygoptera having three tracheal gills at the caudal end of the abdomen, and the Anisoptera having no caudal tracheal gills, being provided with rectal gills instead.

The Odonata form one of the strangest orders of insects with which an entomologist has to deal. Their bizarre form, striking colors, and peculiar habits make them an object of much curiosity on the part of the layman as well as the object of many studies on the part of the scientist. The prevalence of the popular terms, snake-feeders, snake-doctors, and similar names, shows that there are many superstitions concerning the group.

As is well known, the Odonata are predaceous, in all stages, upon other insects, particularly upon those insects annoying to man, the flies and mosquitoes, and in this rôle they must be classed as beneficial. Their harmful activities are few, but they sometimes destroy young fish, they occasionally injure plants by the insertion of eggs, and,

---

*Contributions from the Entomological Laboratories of the University of Illinois No. 53.

most serious of all, they do not discriminate between beneficial and noxious insects, but destroy both. An instance of the fact last mentioned is the recently reported feeding of *Anax junius* on the honeybee. In no case, however, is it probable that the harm done overbalances, or begins to counterbalance, the good which these insects do in the destruction of biting Diptera.

The classification of the nymphs of Zygoptera is in a backward state as compared with the classification of the adults. This is due especially to the fact that immature forms are not easily collected and that their classification is particularly difficult. An intensive study of the nymphal characters has shown that there are, within certain genera, groups of nymphs the species of which are much more closely related to each other than to the members of other groups of the same genus. These groups correspond to groups of adult species in the identification of which the characters of the anal appendages of the male are mostly relied upon. Little attention seems to have been given by taxonomists to the females, and where species are represented in collections by females only it is exceedingly difficult to determine them. Again, when studying nymphs, one is often successful in rearing a number of females, but almost any amount of painstaking work may fail to produce a male. In such cases still more inconvenience is experienced when it is found that the reared females can not be named because of the fact that the published synopses are based largely upon male characters.

It is with a view to clearing up some of the obscure features of the classification and lessening the labor of determination that nymphs and adults, including both sexes, have been considered together and tables prepared for the separation of both.

All obtainable biological data have been added for the sake of completeness; but it is fully realized that the data given here are incomplete, and can only be made complete after many years of diligent study.

Nymphs of several species which are apparently new have been reared in the course of the study and are described herein for the first time. Some of the remaining species which doubtless occur in Illinois but which have not been collected by the writer, have been obtained through the courtesy of various people, and the list has been completed as far as possible in this way.

Certain problems concerned with the nomenclature have presented themselves, the most important of which concerns the adoption of family names. According to the ruling of the International Commission on Zoological Nomenclature (Muttkowski, '10: 15) Agrion re-

places Calopteryx, and the family name Calopterygidae must be abolished. The change has caused much confusion because of the former application of the name Agrionidae; but it seems practically certain that further change would only result in still greater confusion, and the family names as used by Muttkowski are, therefore, adopted without change.

The use of the common names "dragon-fly" and "damsel-fly" in referring to the Anisoptera and Zygoptera respectively, causes no little confusion because of the frequent use of the term dragon-fly to denote the order as a whole. In the following pages, the words Anisoptera and Zygoptera will be used exclusively to designate the subdivisions of the order.

ACKNOWLEDGMENTS

I take pleasure at this point in expressing thanks for the valuable aid which Dr. A. D. MacGillivray has given by his careful supervision of work and thoughtful criticism during the course of the study. Thanks are also due to Dr. S. A. Forbes for granting financial support from the funds of the Illinois State Laboratory of Natural History as well as for the loan of the collection of Zygoptera belonging to that laboratory. I am especially indebted to Mr. E. B. Williamson for his kindness in permitting me to examine his collection of Odonata; and I further wish to thank Dr. E. M. Walker and Dr. J. G. Needham for the loan of specimens of zygopterous nymphs, and Dr. P. P. Calvert for the identification of material sent him.

MORPHOLOGY

NYMPH

The nymphs are distinguishable from all other insects by the possession of three more or less flattened, caudal, tracheal gills. They are slender, delicate insects of the same color as the surrounding vegetation or environment in which they live and at first sight seem hardly capable of the predatory habits of the order. They are usually covered with fine hairs or spinules which collect an ambuscade of dirt and rubbish. Their slender cylindrical abdomens resemble the stems of plants and weeds, and the caudal gills remind one frequently of growths of algae. Such adaptations as these render the insect most inconspicuous in its natural habitat.

Head.—The head of the nymph is somewhat oval or pentagonal in outline when viewed from above, and is usually longer than wide. The sutures are indistinct even in full-grown nymphs with the excep-

tion of the epicranial suture, which is a Y-shaped line on the dorsum of the head, near the caudal margin. Sutures are wanting, separating vertex from occiput, occiput from postgenae, and postgenae from genae. The vertex occupies that part of the dorsum of the head capsule caudad of the arms of the Y; and the occiput and postgenae together, the portion of the caudal aspect of the head not occupied by the occipital foramen and the compound eyes. The genae are the areas mesad of the ventral margins of the compound eyes. They fuse with the postgenae (Fig. 7, pg) near the ventral margin of the head. Extending caudo-dorsad on the caudal aspect from the ventral articulations of each mandible, there is a distinct ridge which disappears near the middle of the head. The trochantins of the mandibles are present as indistinct triangular areas laterad of the bases of the mandibles (Fig. 7, tm).

Compound Eyes.—The compound eyes of the nymphs, like those of the adult, are very large. They occupy perhaps one-third of the dorsal surface of the head, nearly the whole of the lateral surface, and part of the ventral. The facets are hexagonal and similar to those of other insects.

Ocelli.—The ocelli are wanting during nymphal life, but in the later stages the adult ocelli may be seen through the transparent cuticle of the dorsum of the head. Thus it often appears as if the nymph had ocelli when in reality there are none present, as can be proved by an examination of the final exuvium, or by dissection.

Antennae.—The antennae, in all full-grown nymphs, consist of seven segments. The distal segment is short in most species and the connection between it and the preceding one is frequently obscure, so that it seems as if the appendage had only six segments. The first segment is usually thicker than the remaining ones, and in the Agrionidae is as long as all the rest of the segments together. In the Coenagrionidae, the third segment is the longest and each of the segments distad of it is shorter than the segment preceding. The two proximal ones are not constant in length but are always shorter than the third.

Mandibles.—The mandibles are normally hidden from sight by the large labium and the flap-like labrum. They are located on the ventral surface of the head and are well formed for mastication. They are irregular in outline, though somewhat rectangular, bearing four short, strong teeth along the distal margin and several smaller teeth mesad and proximad of these.

Maxillae.—The maxillae (Fig. 22) are attached to the ventral surface of the head and the following parts are distinguishable: a

triangular cardo (cd); a narrow sclerite which may be known as the cardella (cl); and a long, oblong stipes, to the distal end of which are attached two appendages representing palpus, lacinia, and galea. The lateral, narrower one of these (mxp), the palpus, bears on its surface a number of strong setae. There is sometimes a distinct swelling at the base of it but there is no distinct suture between the proximal and distal portions. The remaining process, regarded as the fused galea and lacinia (glc), is much broader at the base and tapers considerably at the apex, where it bears about five strong hooks. It is provided with two rows of weaker setae extending proximad from the hooks. The identification of this piece as fused galea and lacinia is due to the supposed occurrence, in adults of certain species, of a suture extending across it from the proximal to the distal end. So far no case has come to my notice in which this suture is present, but a study of Ephemerida (Morgan, '13) and Plecoptera (Fig. 31) on the other hand, proves conclusively that the piece has been correctly interpreted.

Labium.—The labium differs greatly from that of the ordinary insect in being free from the head at the point of articulation of the submentum, and in being folded so that mentum and submentum are approximated when the piece is at rest. It is applied to the ventral surface of the head, forming a sort of mask; and an idea of its general location and shape may be obtained from Figures 1–4, 6, and 7.

Several forms of labia occur in the suborder which, although similar in general construction, differ in certain particulars. The forms of the lateral arms or labial palpi, the mentum, and the submentum are different enough in different species to enable one to determine the family, and sometimes the genus, at a glance (Figs. 8–13). The submentum is a hollow tube of cuticle (Figs, 2, 4; sm) articulating at its proximal angles with the ventral wall of the head capsule. It is filled with muscles for the extension and retraction of the labium as a whole, and varies in shape from cylindrical to flat, and from comparatively short, hardly extending caudad of the posterior margin of the head, to long and slender, reaching caudad of the metacoxae. The mentum-ligula, or median lobe (Figs. 8, 9; ml), is likewise filled with heavy muscles which move the labial palpi. It varies in shape, in the degree of the contraction proximad, and, more important for purposes of classification, in the number of mental setae (Figs. 10, 12, 13; ms). The median lobe is sometimes notched or cleft at the apex but is more frequently without indentation. The glossae and paraglossae are present at the distal end of the labium, but the suture between them and the mentum is in

most cases indistinct. The latter, however, seems to be represented in species having the deeper median clefts. The palpi are present in the so-called "lateral arms", the distal segments being represented by the movable hooks (Figs. 8, 9; lp_2). The lateral arms also bear a number of raptorial setae in some species (Fig. 10). In capturing prey, which consists of mosquito and other soft aquatic larvae, the nymph swings out the hinged labium, opening and closing the lateral arms like a pair of jaws. The victim is then drawn back toward the mouth and the heavy maxillae and mandibles finish the work.

Labial Muscles.—The muscles operating the labium have been studied by few, and studies that have been made seem incomplete. It has therefore seemed advisable to examine them in detail. The structures have been determined by means of cross and longitudinal sections and verified as far as possible by gross dissections.

The median lobe (Figs. 1, 2; ml) contains four large muscles for operating the lateral arms. These are attached proximad directly to the dorsal wall of the submentum, dorsad of the hinge (Fig. 4). At the point of attachment to the labial palpi, the muscles are usually modified to form tendons. With the submentum there are also two pairs of muscles, which, though not as large as those of the median lobe, play an even more important part in the operation of the piece. The points of insertion of the mental muscles are of especial interest and give clues to the actual function of each muscle. The dorsal inner pair (Figs. 2, 4) is attached proximad to the tentorium and distad just above the hinge which is between the median lobe and the submentum. The remaining, or ventral, pair is attached to the chitinous ligament or rod described below—a structure present only in the Odonata. The rod (Figs. 3, 4, 7; cr) is unpaired and is attached to the ventral wall of the head just caudad of the hypopharynx. It extends obliquely caudad and dorsad in the plane of the meson and is attached again to the dorsal wall of the submentum, at which point it expands in such a way as to form the top of a T. The ventral pair of muscles are inserted on the base of the chitinous rod (Fig. 4). From this point they extend over the mento-submental hinge and attach themselves to the ventral wall of the median lobe. A third pair of muscles, present at the base of the submentum, is attached to the ventral wall of the head caudad of the hypopharynx, extends caudad and dorsad, and is inserted on or near the tentorium.

The exact function of each of the muscles contained in the submentum is difficult to explain, and it is probable that no single pair can be said to produce a given result with the exception of those operating the labial palpi. Thus it can be seen that the oblique muscles at

the base of the labium are important in throwing the submentum away from the head. In this, however, they are aided by the presence of the oblique, chitinous rod and by the contraction of the dorso-submental muscles. The action of the ventral pair seems reasonably clear, as it can, by contraction, swing the mentum back towards the submentum, and by action in conjunction with the chitinous rod, swing the submentum back towards the head. The mentum is swung out away from the submentum mainly by the action of the dorsal submental muscles which are attached to it above the hinge and in this capacity are aided to some extent by the contraction of the muscles within the mentum, especially those which operate the labial palpi.

Glossae and Paraglossae.—The glossae and paraglossae are fused and the suture is untraceable except in the embryo (Butler, '04). The nymph of Agrion shows a fold extending between the labial palpi beneath the median cleft. This fold probably represents all that is left of the suture between mentum and paraglossae. In other species the course of the suture is marked by a row of setae, the mental setae. The area occupied by the submentum is indefinite, but it is probable that the mental setae, even if secondary in origin and occurring only in the more specialized forms, are near the location of the original mento-paraglossal suture. The latter suture has been thought to become approximated to the distal border of the median lobe, but this seems doubtful after comparisons of nymphal and embryonic labia (Butler, '04).

Labial Palpi.—The palpi of the labium are represented by the lateral lobes, (Figs. 8, 9; lp_1, lp_2). These lobes bear at their distal ends a number of fixed hooks, which are simple in some cases, but may become modified in others, for instance in the Coenagrionidae, in which the middle hook is replaced by a blunt process with teeth at the apex. That the fixed hooks have not the same origin as the movable ones, is shown by the fact that the latter bear, in certain nymphs, a number of long setae. The movable hook has been considered (Butler, '04) as a modified palpal segment, and this interpretation is undoubtedly the correct one. The proximal segment or body of the lateral arms also bears in many species of nymphs a row of long setae, the number of which is used extensively in the classification of the group. In Agrion, however, this row of setae is wanting and the lateral lobe bears only two small setae near the base of the movable hook. The body of the mentum is also provided with rows of setae in all genera except Argia, Agrion, and Hetaerina, the bristles being in two divergent lines beginning near the meson slightly distad of the center and reaching nearly to the proximal end of the labial palpi.

Median Lobe.—This term is used for convenience and includes the fused glossae and paraglossae.

Hypopharynx.—Perhaps the most conspicuous portion of the hypopharynx is a circular pad between the tips of the maxillae, and easily seen on raising the mentum-ligula. It is covered with minute setae possibly indicating the location of sensory organs. The pad has been given the name laminula by Berlese, and corresponds to the lingua of other insects. However, it is somewhat difficult to homologize any part of it with other forms on account of the very great modification.

Propharynx.—The propharynx lies closely applied to the ental surface of the labrum, and has essentially the same shape as the latter. It possesses no features worthy of mention.

Prothorax.—The prothorax, the large segment just caudad of the head, is preceded by a smaller segment, the microthorax, which forms the neck. The sclerites of the microthorax are not well developed in the nymph. Most of the sutures of the prothorax are also indistinct and are represented by furrows in the cuticle. The pronotum (Fig. 23, pme) is divided by depressions into caudal, mesal, and cephalic areas. The caudal lobe is, in most species, a narrow transverse area along the caudal margin; the mesal lobe comprises the larger part of the pronotum, and is usually divided by a median furrow into two lateral areas; and the cephalic lobe includes the transverse area cephalad of the median lobes and caudad of the cephalic margin. The furrow which marks the caudal boundary of the cephalic lobe and the median furrow of the pronotum form a Y, and at the point of union of the three arms there is usually an invagination. The proepimera and proepisterna are areas ventrad of the pronotum on either side and dorsad of the coxae, and are separated by furrows which are very distinct in some genera, especially Lestes. In this genus the furrow separating the two pieces extends dorsad a short distance from the point of articulation of the procoxae and the procoxal process (Fig. 25, pcxp), bends slightly cephalad and then caudad, extending to the caudal margin of the prothorax. In the Coenagrioninae there is often a secondary ridge extending dorsad from the procoxal process but this does not mark the boundary between proepisternum and proepimeron. The prosternum is the area between the procoxae, and is much broader than that of the adult. There is no indication of distinct areas or sclerites, but near the caudal margin of the prosternum and between the coxae are the two invaginations of the furca (Fig. 24, fi).

Mesothorax and Metathorax.—The mesothorax and metathorax are greatly different from the common type of thorax, in consequence of an approximation of the mesepisterna on the dorso-meson in the

mesothorax and an approximation of the epimera on the ventro-meson in the metathorax; all of which is accompanied by an enormous development of muscles within the thorax in preparation for the active life of the adult. The wing-cases, too, are early approximated, and there is a corresponding reduction in the size of the mesonotum and metanotum.

Mesonotum.—The mesonotum is divided into two regions by the closing together of the mesepisterna. The cephalic one, the prescutum, just caudad of the pronotum, is a shield-shaped plate with slightly projecting cephalo-lateral angles. On the cephalic margin of this piece on the meson there is an invagination, the prephragma, which, however, is usually not well developed in the nymph. The second portion of the mesoscutum lies between the cephalic pair of wing-cases. This represents combined scutum, scutellum, and postscutellum. It is narrowed cephalad, has a slight projection on each cephalo-lateral angle, the anterior wing-processes (Fig. 21, awp), and a similar, longer, one on each caudo-lateral angle, the posterior wing-processes (Fig. 21, pwp). Near the cephalic margin on the meson is an invagination indicating the location of the mesophragma. Immediately caudad of the mesoscutum and between the second pair of wing-cases is the metascutum. This is similar in shape to the caudal sclerite of the mesoscutum, though somewhat larger, and possesses similar wing-processes on its lateral angles. There is no subdivision of the metascutum, but there is a deep invagination on the meson near the cephalic margin—the metaphragma.

Mesothoracic Spiracles.—These are located just laterad of the prescutum and are always hidden to a greater or less extent by the overlapping pronotum. Large tracheae are connected with them and the spiracles are doubtless functional during nymphal life. The meso-stigmal plates are wanting in the nymph, and their derivation will be discussed later, in the description of the adult.

Mesopleura.—These sclerites, occupying somewhat more than the cephalic half of the lateral aspects of the pleura, are approximate on their dorsal margin between the prescutum and the wing-cases. The dorsal border extends from the mesostigma caudad to the second pair of wing-cases. The cephalic margin follows the caudal margin of the pronotum and extends ventrad from the mesostigma to the mesocoxae. The ventral border follows the contour of the coxal cavity; and the caudal border, forming a suture which may be known as the inter-pleural suture (Fig. 25, insu), extends from between the mesocoxae and metacoxae dorso-caudad to near the base of the second pair of wings. The mesopleura are each divided by three furrows into three

areas, two of which, the cephalo-dorsal and cephalo-ventral (Fig. 25, seps, ieps), comprise the episterna, and the caudo-ventral, the epimera (Fig. 25, epm). The ventral areas of the episterna (ieps) are known to odonatologists as the infraepisterna, and the dorsal ones incorrectly as the episterna. For convenience in designating the parts the latter may be known as the supraepisterna (seps).

Mesosternum.—The mesosternum, that area between the meso-coxae, the caudal margins of the prosternum, and the cephalic margins of the metasternum, is not divided into separate areas, but the furcae are present and the deep furcal invaginations are very distinct (Fig. 24, fi).

Metapleura.—The boundaries of each metapleuron are the interpleural suture, the metacoxae, the metathoracic wing-cases, and the pleura and sternum of the first abdominal segment. The sclerites are each divided into three parts, the cephalic two comprising the metepisternum (supraepisternum and infraepisternum), and the caudal one, the metepimeron. The metathoracic spiracles are located on these pieces near the union of the dorsal border of the metinfraepisternum with the interpleural suture.

Metasternum.—The metasternum (Fig. 24, mtst) is similar in shape to the mesosternum, but is divided by sutures into three areas. The invaginations of the metafurcae are also prominent and a suture extends caudo-mesad from each. The two sutures unite on the meson, extend caudad for a short distance, separate again, and extend laterad and caudad of the coxae. The areas on each side of the mesal line are the two halves of the sternellum (mtsm). Caudad of the sternellum is a broad sclerite possibly representing the first abdominal segment. This may be known as the intersternum (Fig. 24, ints). There is no corresponding sclerite on the dorsum caudad of the thorax, but it may be that the latter portion has been lost. If, however, the intersternum be considered as a vestige of an abdominal segment, it will be found by actual count that there are twelve segments represented in the abdomen of the nymph, a fact which makes one skeptical of the above interpretation. In some species, the area is membranous, and it is possible that the sclerite is nothing more than accessory membrane which has subsequently become chitinized.

Trochantins.—The trochantins are wanting in the Zygoptera, and the mesal part of the coxae articulates directly with the sterna.

Legs.—The legs are usually slender and not well adapted for capturing prey, the labium being wholly relied upon for that purpose. The coxae are nearly spherical and slightly compressed. The trochanter consists of two segments. The proximal segment is narrow and

capable of being telescoped into the coxa. The second segment is longer, and its ventral length is greater than its dorsal. The femora are subequal in length, the posterior being slightly longer, especially in Argia and the Lestinae. The tibiae are also nearly equal in length and are slender and cylindrical. The tarsi have three segments. The proximal segment is short and is extended below the second segment so that its ventral length is greater than its dorsal. The second segment is usually about twice the length of the proximal but, like the proximal one, is extended on the ventral side. The third segment is longer than either of the two proximal ones, being in some cases nearly twice as long as the second and four times as long as the first. At the distal end of the third segment, on the ventral surface, there can be found a small sclerite which probably represents an extra tarsal segment and is known as the pretarsus (Fig. 19, pta). It is drawn out distally into a slender process. The tarsal claws vary to some extent in length but are always sharply pointed and somewhat swollen at base. They are never bifid at the tip as in the adult. The legs of the nymphs never bear the long spines characteristic of the adult but, instead, there are weak setae or short spinules which collect particles of dirt and enable the insect to hide with ease. In the Agrioninae, there are to be found short, minute, three-pointed scales at the ends of the tibiae, the function of which is obscure (Fig. 19). The tarsi in all species possess two to four rows of short setae on the ventral surface. The markings of the legs vary with the genus, but consist largely of black rings on the femora and tibiae. In Agrion, nearly the whole of the femur is dark except a whitish ring near the apex. The tibial bands are mostly restricted to the proximal third and are lacking in most species.

Wing-cases.—The wing-cases of Zygoptera appear early and at the completion of nymphal life usually extend as far caudad as the fifth or sixth abdominal segment (Fig. 25, wc). The tracheation of the pad is often obscure but the veins are sometimes plain enough to be of value in identification. Ontogenetic studies of the wings can only be made at intervals during the growth of the nymph, the obscure nature of the contents of the pad making such study difficult during the greater part of the time. In no case do we find the radial sector actually crossing over the media as in the Anisoptera, and, as pointed out by Needham ('03), the subnodal cross-vein formed by the proximal end of the radial sector has been reduced and lost. The distal portion, however, may be seen in Lestes, but not usually in other species, and branches from the second media a short distance from its separation from the first media (Fig. 14, R_s).

Abdomen.—The abdomen is always composed of ten complete body-rings. The eleventh segment, seen best in Lestes, is represented by the small basal processes (Figs. 5, 18; A_{11}) to which the caudal gills are attached. The twelfth segment, supposed to be present in the minute sclerites bounding the anus, is apparently wanting or indistinct. Each body-ring is without sutures but is roughly divided by the lateral carinae into sternal and tergal areas. In the Coenagrionidae, the lateral carinae of the first eight segments are known as lateral keels (Fig. 25, lk). In Lestes, the caudal extremity of each keel is sometimes drawn out into short setae and is setose or hairy along the margins. Marginal setae are also present in the Coenagrionidae but the heavy caudal setae are wanting.

Sexual Appendages.—It is claimed that the sexual appendages of the nymphs (Balfour-Browne, '09) can not be seen and differentiated until about the time of the seventh molt. From personal observations, however, it would seem that the appendages appear much earlier than this, and possibly as early as the fourth molt. The male genital appendages are located on the ninth abdominal sternum and consist of a simple pair of short, sharp, conical styli, near the ventro-meson. There is also an indication of the location of the male copulatory organs on the ventral surface of the second and third sterna (Fig. 24, ag), though nothing definite is formed there until the adult emerges. The ovipositor of the female is composed of six processes developing from the eighth and ninth sterna (Figs. 5, 18; oce, oca). Four of these are similar in appearance, being slender, curved, blunt projections extending commonly beyond the end of the ninth segment and frequently beyond the apex of the tenth. Laterad of this double pair of inner valves, can be found a pair of lateral styli which differ from the inner valves in being pointed at the tip and much broader at the base. The origin of the four median valves is partly from the eighth abdominal segment and partly from the ninth, the external ventral pair (oce) being derived from the eighth.

Caudal Gills.—The caudal tracheal gills are present in the earliest stages and are reported to have been seen in the embryo. They vary from linear to broadly obovate in outline and from triangular to linear in cross-section. Cuticular pigmentation, if any, is either in transverse bands or is diffused over the entire gill. In many cases the tracheae contain pigment, which causes them to stand out in marked contrast to the rest of the gill. Along the margin of the gills are rows of spines or setae, which differ in number and extent in different species. The lateral median ridges of the flat type of gills also possess rows of setae, but they are difficult to observe and are of little

importance in classification. Two or more main tracheal trunks enter each gill and send off branches towards the margins. The mode of branching of the trachea is characteristic of many species, as is also the degree of pigmentation.

A closed tracheal system has been considered possible and even probable in the Zygoptera, but thus far no connection has been traced by me, with the highest magnification obtainable, between the ends of the branches of the tracheae. The normal function of the gills is one of respiration, the minute tracheae being supposedly able to take up the oxygen from the water and to supply the animal with a sufficient quantity of the gas. Observations show, however, that complete loss of gills does not injure the insect to any appreciable extent; and it has been suggested that they also have cuticular and possibly rectal respiration, the latter thought to have been demonstrated in the Agrionidae. In young nymphs there is a pulsating movement in the region of the rectum, but cross-sections of the abdomen of *Ischnura verticalis* and several species of Enallagma show that there is no connection of the tracheal system with the alimentary tract other than a few small branches. What seems to be a more serious impairment of life activities in the loss of the gills is the decreased power of locomotion which the insect suffers, the gills having the same importance as the tail of a fish. Loss of gills frequently occurs, in which case new ones are produced; but these appear only after the insect has molted, always remain small, and are usually abnormal in figuration and tracheation (Fig. 77a). For different types of gills see Figures 48–72, 75–77a, and 80.

Cerci.—Anal appendages corresponding to cerci are present dorsolaterad of each lateral gill and vary in shape from tubercular to styliform (Figs. 5, 18; ci).

ADULT

The adults of Odonata are distinguishable from all other orders of insects by the type of their wing venation. The wing is characterized by the presence of a nodus and a stigma and a large number of secondary cross-veins. The presence of accessory genitalia on the second abdominal segment of the male is another unique feature. The Zygoptera are for the most part separated from the suborder Anisoptera by the habit of folding their wings vertically when at rest. The abdomen is much more slender than that of the Anisoptera, and the wings are different in being contracted or petiolate at the base.

Head.—In general appearance the head is wide and the eyes are very prominent, and as the head moves on a point of the microthorax its angle of rotation is very great. The epicranial furrow is present

on the dorsum near the caudal margin, similar in position to that of the nymph, and is, as a rule, indistinct unless the head is specially prepared in caustic potash. The furrow begins near the caudal margin of the dorsum, extends cephalad a short distance, forks, and extends latero-cephalad, caudad of the ocelli, to the margins of the compound eyes (Fig. 32, epcs). It can not be traced to the occipital foramen, but the homology of the furrow as a whole can not be doubted. There are three ocelli (o) cephalad of the Y, which are sometimes elevated above the surface of the head forming the so-called ocellar area. A furrow extends cephalad from the angle of the Y between the lateral ocelli and forks just caudad of the median ocellus. This furrow is present in many orders of insects, but its true homology is not known. The front includes that portion of the dorsal aspect cephalad of the epicranial Y, between the compound eyes and cephalo-ventrad to the fronto-clypeal suture (Fig. 32, f). Cephalad of the median ocellus there is always a short, deep, transverse furrow which, although present in most Odonata, must not be mistaken for a suture. The fronto-clypeal suture does not reach the margins of the compound eyes on either side. There is always a polished area on each side of the clypeus, which is a portion of the gena (Fig. 32, gn). The clypeus (Fig. 32, cly) extends ventrad of the fronto-clypeal suture and is divided into two parts by a transverse median ridge. The dorsal part, often dark and heavily chitinized, is the postclypeus; the ventral one, more weakly chitinized and often wrinkled, is the anteclypeus. The clypeo-labral suture separates the clypeus from the sclerite ventrad of it, the labrum (Fig. 32, lbr). This sclerite is only slightly bilobed in most species of Zygoptera, the ventral margin is directed caudad, and the lateral margins are convexly rounded. Laterad of the bases of the mandibles, which lie at either side of the clypeus and labrum, there are small semi-ovate sclerites, the trochantins of the mandibles (Fig. 32, tm). The fronto-genal sutures are indistinct, but are represented by furrows extending from the dorsal articulations of the mandibles to the antennal fossae and laterad to the compound eyes. That portion of the head on the dorsum and caudad of the arms of the epicranial Y, is the vertex (Fig. 32, vx), but it is not separated by a distinct suture from the occiput, which occupies the dorsal half or third of the caudal aspect (Fig. 30, oct). The postgenae, which occupy the ventral half of this aspect are separated from the genae by the oblique ridge mentioned above. There is another ridge starting from the ventral condyle of the mandibles (Fig. 30, ocr) but extending dorsad instead of latero-dorsad. This ridge disappears near the middle of the head.

Ocelli.—The location of the ocelli has already been described. They are moderately large, elliptical, and grouped in a triangle (Fig. 32, o).

Compound Eyes.—The compound eyes (Figs. 30, 32; ce) are large and contain a large number of ommatidia. They are located mostly on the lateral aspects of the head, but sometimes extend well onto the dorsum.

Antennae.—The antennae (Fig. 32, ant) are usually composed of four segments. The condyle of the scape is especially prominent. The two terminal segments are styliform and resemble a single segment. The greatest variation in the different segments lies in the length of the first, which ranges from hardly more than half that of the second segment, to an equal or greater length than that. There is also a less noticeable variation in the length of the third segment.

Labium.—The labium (Fig. 37) is the ventral movable appendage of the head. It is a broad flat piece and covers nearly one-fourth the entire ventral surface. The submentum (sm), the proximal sclerite, is attached to the head and neck and comprises that part of the labium dorsad of the hinge when the labium is at rest. Immediately cephalad of the hinge there is a small, almost linear, transverse area, the mentum (me). Beyond this there is a large subtriangular piece with a deep median, distal cleft and a suture-like furrow extending to the proximal end. This piece is the median lobe (ml) and represents fused glossae and paraglossae. On each side of this median lobe there are heavy blade-like lobes, the labial palpi, which connect with the proximal part of the median lobe. The fixed proximal segment is the palpiger (pl), the large movable distal portion is the proximal segment of the palpus, and the short blunt movable appendage borne by the proximal segment is the distal segment (lp_1, lp_2). There is a long, sharp, fixed hook mesad of the distal segment of the palpus, which in most cases is longer than the distal segment of the palpus.

Maxillae.—The maxillae are just above the labium, one on each side of the mouth-opening. When the labium is applied to the ventral surface of the head, the maxillae are hidden, except the cardines and the caudal half of the stipites. The cardo and cardella are bent at an angle to the stipes, but when removed from the head along with the rest of the maxilla they are seen as two small sclerites attached to the proximal end of the stipes, the cardo being triangular and attached to the stipes, and the mesal side of the triangle forming the suture between cardo and cardella. The cardella (Fig. 28, cl) is a very irregular sclerite which articulates with the head capsule. Attached to the distal border of the stipes, the quadrangular sclerite which forms the body of the maxilla, are two appendages, the lateral more slender two-

segmented appendage being the palpus, the broader one, the fused galea and lacinia. The palpus has a number of large setae scattered over the surface. The galea-lacinia is more or less compressed, and the distal margin has about six irregularly placed hooks arranged in two rows. A marginal fringe of heavy setae extends proximad from the hooks. In Hetaerina, if the galea-lacinia be placed on edge, there will be seen a strong indentation between the two rows of hooks, an indication of the fused condition of the piece. A study of Plecoptera (Fig. 31) and Ephemerida (Morgan, '13) offers convincing reasons for the interpretation of this piece as galea and lacinia fused, as compared with a belief in the reduction of the galea, or in the fusion of this with the palpus instead of the lacinia, or in the reduction of the palpus. All degrees of fusion, from complete separation (Fig. 31) to complete fusion and disappearance of the suture, may be had in series selected from these two orders.

Mandibles (Fig. 30, md).—All of each mandible is hidden beneath the labrum and labium except the lateral surface. The teeth are strong and heavily chitinized and the distal margins are divided into two projections, the cephalic one bearing a number of teeth, the caudal one with a number of teeth and cutting edges arranged in the shape of a Z.

Hypopharynx (Fig. 30, hp).—The visible portion of the hypopharynx appears as a semicircular part between the tips of the maxillae. It is much more heavily chitinized than that of the nymph, and usually has a number of long setae attached to each lateral surface.

Propharynx.—The propharynx is closely applied to the interior of the labrum and clypeus and presents no features of interest.

Microthorax (Figs. 27, 29, 36, 39).—The microthorax comprises the neck sclerites, and is much reduced in the Zygoptera. The dorsal and ventral sclerites (notum and sternum) and the episterna are wanting. The only portions remaining are the conspicuous lateral plates, the epimera (min). In many species the epimera are much widened on the caudal third, and this portion is almost completely divided by a deep cephalic indentation. The indentation separates from the main part of the epimera a bell-shaped dorsal part which serves as a buffer for the head and is to some extent freely movable. The ventral part is slightly larger than the dorsal buffer, but is thrown into folds, and the cephalic part of the ventral piece is drawn out into a long tapering point. The tips of the epimera are fastened together by ligaments and the head rotates upon the apices of the two together, which rest against the body of the tentorium.

Thorax.—The thorax comprises the three body-segments caudad of the microthorax. The first conspicuous ring is the prothorax. The

mesothorax and metathorax together form the division caudad of the prothorax and are so closely united that they appear as one segment.

Prothorax (Figs. 27, 29, 36, 39; 41, pn).—The lateral margins of the pronotum are usually indefinite because of the disappearance of the noto-pleural suture or because of excessive pigment. Lestes is probably the best form in which to study the prothorax on account of the clearly marked sutures between the sclerites. The caudal margin of the prothoracic dorsum extends caudad as a thin blade-like projection. There is a suture or furrow which extends cephalad from the lateral limit of the blade-like projection and marks the lateral extent of the pronotum (pn). Shortly cephalad of the caudal margin of the pronotum and parallel to it there is a deep furrow which resembles a suture and extends from one lateral margin to the other. The area between this fold and the caudal margin is the caudal lobe of the pronotum. Cephalad of the lateral extremities of the caudal lobe, the suture marking the lateral boundary of the pronotum arches dorsad a little and reaches the cephalic margin of the prothorax at the base of the microepimeron. At this point there is a second transverse fold in the pronotum which is, however, large and more irregular than the caudal one mentioned above. The area between it and the cephalic margin is the cephalic lobe. Near the dorso-meson, the cephalic fold bends caudad and there is a deep invagination here, the prophragma. Between the prophragma and the caudal lobe there is a furrow which separates the remaining portion of the notum, not included by the caudal and cephalic lobes, into two equal, mesal or median lobes (Figs. 36, 39; pme). The principal variations in the prothorax lie in differences in the caudal lobe and in the sculpturing of the dorsal surfaces of the mesal lobes. In Nehalennia the caudal lobe is deeply incised and in Chromagrion (Fig. 170) this lobe is not only incised, but there are also two flat points, projecting laterad, one on each mesal lobe. Many other modifications also occur, most of which are secondary sexual characters.

Propleura (Figs. 36, 39).—The propleura, those areas ventrad of the pronotum and dorsad of the coxae, are each subdivided into three areas. Extending dorsad from the lateral procoxal articulation (pcxp) there is a distinct suture which becomes indistinct before reaching the lateral margin of the pronotum. This suture (pps), the propleural suture, is usually depressed and the depression is continuous with that forming the cephalic fold of the pronotum. Caudad of the propleural suture there is a large, rounded area which forms the caudolateral angles of the prothorax, and ventrad of this is a small, falcate area. Both areas constitute the proepimeron (pepn), there being no

real suture between the two. Cephalad of the propleural suture is a somewhat triangular area, the proepisternum (peps), the cephalo-ventral angles of which are drawn out and extend ventrad in front of the procoxae. The cephalo-ventral arms of the proepisterna are fused with the propreepisterna. Between the dorsal triangular portion of the preepisterna and the microepimera is a small, much-wrinkled area, which appears to be composed of a number of sclerites. This, however, belongs to the proepisternum.

Prosternum (Figs. 27, 29).—The cephalo-ventral arms of the episterna, as described above, extend ventro-cephalad and become approximate but not quite contiguous on the ventro-meson. Caudad of the approximated ends of the episterna there is a large shield-shaped ventral sclerite the caudal margin of which is concave. This is the fused sternum and presternum (prst). The caudo-lateral angles are usually acute, and at the tips of these angles are found the deep invaginations of the furcae (fi). Caudad of the sternum and between the furcae is a heavily pigmented chitinized area, the sternellum, which extends about as far caudad as the caudal margins of the coxae. In some cases there is within the sternellum an elliptical or oval depressed area much resembling a true sclerite. This is a secondary formation. On each side of the meson, caudad of the sternellum, is a heavily chitinized bar which extends latero-caudad and is attached to the mesothorax. These bars represent the furcella (fl).

Mesothorax and Metathorax (Figs. 40–47).—This division of the thorax bears the two pairs of wings and the second and third pairs of legs. A glance at the mesothorax and metathorax of any dragonfly will show that the wings, instead of being borne on the mid-dorsum of the thorax, are situated far to the rear and are inserted just above the cephalic margin of the first abdominal segment. This change in wing position has brought changes in the structure of the thorax as a whole, including the reduction of primary sutures and the appearance of many secondary ones, and as a result the external thoracic skeleton of Odonata is as complex as that of the highly specialized Hymenoptera and Diptera.

Mesnotum (Figs. 41, 44, 46, 47).—As has been mentioned in the nymphal description, the mesepisterna are approximate on the dorso-meson. In the adult the two have united and fused, a single suture being left, extending from near the caudal margin of the pronotum to the wing bases. In some cases this suture is slightly elevated, forming a carina (dc), but it is often flattened at the point of fusion of the two pieces and the suture nearly obliterated. Cephalad of the dorsal carina there is a small somewhat rhomboidal area, the prescutum

(mscl). There is a deep invagination near its cephalic angle but no invaginations of the internal skeleton occur here. Caudad of the caudal extremity of the dorsal carina and adjacent to the wing bases there are two small, frequently subcrescentic pieces which are approximate on the mesal margins and extend well towards the first lateral suture of the thorax. These are the combined mesepisternal paraptera (p). Caudad of the mesepisternal paraptera, but on a distinctly lower level and between the first pair of wings, is the second portion of the mesonotum, which consists of a number of irregular hummocks separated by depressions, sutures, and ridges. Just caudad of the paraptera on the dorso-meson there is a very deep invagination of the mesaphragma, which is situated near the cephalic margin of the mesoscutum (mscc). At this point the mesoscutum is narrow, but widens soon after extending caudad a short distance and forms a process, the anterior wing-process. From this point the margin extends caudad and forms a similar process, the posterior wing-process. The caudal boundary of the scutum is formed by a heavy chitinous line, bent caudad and extending from side to side between the caudal wing-processes. From the caudal wing-processes the lateral margins of the mesonotum, now the scutellum, extend caudad to the point of entrance of the spring-vein (Figs. 46, 47; spn) which always marks the caudal margin of this sclerite. The central portion of the scutellum is elevated to form a sort of knob, which is heavily chitinized. The portions on either side of this are depressed and as a rule less heavily chitinized than the elevated portion. The area caudad of the spring-vein is the postscutellum (mopl), the latter extending as far as the deep fold which forms the cephalic border of the metaprescutum.

Metanotum (Figs. 46, 47).—The metaprescutum (psct) is a narrow, transverse, heavily chitinized sclerite forming the cephalic margin of the metanotum. It is in great part covered by the membranous postscutellum of the mesonotum but can usually be seen through the latter. On the lateral angles, there are slight ental projections. Caudad of the transverse prescutum, there are four large areas composing the scutum (mtsc) and three deep longitudinal folds which mark off the four areas, but no primary sutures. There is also a somewhat irregular area caudad of the four larger ones. The caudal margin of the scutum is depressed laterad, and the latero-caudal angles project and form the anterior wing-processes. The metascutellum (masl) is similar to the mesoscutellum (mosl), the caudal boundary being marked by a spring-vein (spn) and the sclerite, as in the former case, having a raised central portion and depressed lateral ones. The postscu-

tellum comprises the area caudad of the spring-vein and cephalad of the first abdominal segment.

Mesothoracic Spiracles and Mesostigmal Plates (Figs. 41, 43–45, 212–216).—The mesothoracic spiracles of Zygoptera are large and have exceedingly large tracheal trunks connected with them. As in the nymph, the spiracles have migrated dorsad and are located near the lateral angles of the mesoprescutum and beneath the projecting caudal margins of the pronotum. Adjacent to the spiracle on two sides, are two heavy plates, the ventral one of which is highly polished (Fig. 45, mstv), allowing the prothorax to play upon it to a certain extent. The caudal plates (mstg) are usually triangular and assume a variety of forms in different species. Both of these plates belong to the peritreme of the spiracle. The caudal plate has been assumed by Snodgrass ('09) to be homologous with the depressed area in Anisoptera which extends across the dorsum just caudad of the pronotum. A study of the nymphs of Anisoptera proves conclusively that such is not the case, for in the nymph the depressed area may be observed to develop from the mesepisternum. Another possibility in the derivation of the caudal plates is that they have arisen from the mesoprescutum, and the wide depressed area of Anisoptera may also have had the same origin. This is strongly supported by the apparent disappearance of all traces of the prescutum in the adults. There is, however, a remnant of the prescutum in the adults of Gomphus where the area occupied by the prescutum lies entirely within the transverse depression and the true stigmal plate is closely applied to the stigma. From this it seems that the depressed area of Anisoptera can not be homologous with the spiracular plates of the Zygoptera, but that it must have developed simply from a depression of the mesepisterna.

Use has been made of the caudal stigmal plates in the classification, especially in the case of the females, of the genus Argia. Kennedy ('02a) and Calvert (Calvert and Hagen, '02:103) were the first to call attention to these plates in America, but their use was hinted at as long ago as 1865 by de Selys ('65: 381). In the genus Argia the caudomesal angles are the variable parts of the sclerites. There is considerable difference also in the plates of females of the Coenagrionidae, and individuals of this sex may often be separated by the use of this character. In the Lestinae and Agrionidae, the character seems to be without value, which fact makes the members of the genus Lestes, at least, one of the most difficult of all genera of Zygoptera to determine.

Mesopleura (Figs. 43, 45).—The mesopleura are closely united to the metapleura in most Zygoptera and the interpleural suture has been lost in many cases. This suture can be traced for its full length

only in the family Agrionidae (Fig. 45, insu), in which it extends from a point between the mesocoxae and metacoxae, caudo-dorsad to the caudal margin of the first pair of wings.

Mesepisterna (Figs. 43, 45).—The mesopleural suture, dividing the mesopleura into episterna and epimera, may be traced by locating the lateral articulation of the mesocoxae (Fig. 40, mcp) and the mesopleural wing-process (wp)—a heavily chitinized process extending from the caudo-dorsal margin of the thorax into the membrane at the base of the first pair of wings. The suture will be found to extend cephalad, beginning at the wing-process, parallel to the dorsal carina, as far as the cephalic third of the mesothorax, where it apparently forks, and sends one branch cephalad and the other ventrad to the coxal process (mcp). The horizontal fork is a secondary suture and separates the small sclerite above the coxae, the infraepisternum (ieps), from the rather large oblong sclerite, the supraepisternum (seps).

Mesepimera (Figs. 43, 45).—The mesepimera lie caudo-ventrad of the mesopleural sutures. In the Coenagrionidae they are fused with the metepisterna and the interpleural suture is obsolete except near the wing bases. In the Agrionidae the interpleural suture is distinct throughout its course, and the metepimera are then elongate sclerites with the dorso-cephalic angles considerably rounded.

Metapleura.—The key to the metapleura is the metapleural suture, which may be traced in a similar manner to the mesopleural suture. This may be done by finding the metacoxal articulation and the metapleural wing-process (wp), situated at the base of the second pair of wings, and following the suture between the two points.

Metepisterna (Figs. 43, 45).—The metepisterna are those portions of the metapleura cephalad and dorsad of the metapleural suture (Fig. 45, mtsu). Like the mesepisterna they are divided into two separate sclerites, a small one dorsad of and adjacent to the coxae, the metinfraepisternum, and a larger, elongate one dorsad of the metinfraepisternum and extending from the cephalic margin of the latter caudo-dorsad to the bases of the wings—the metasupraepisternum (seps). The latter is narrowed to about half its width above the infraepisternum and usually bears the metathoracic spiracles (Fig. 43, mtsl) within the constricted portion. In many species there is a secondary suture extending between the spiracle and the metapleural suture (Fig. 45).

Metepimera (Figs. 43, 45).—Caudo-ventrad of the metapleural suture is the metepimeron. The metepimera are contiguous on the ventro-meson. In the Agrionidae the boundaries of the sclerite, beginning with the metacoxal process (mtcp), may be indicated as fol-

lows:—The margin extends ventro-mesad (Fig. 40), meeting its fellow from the opposite side on the meson, then extends caudad halfway from the coxae to the first abdominal segment, bends laterad to the elevated lateral carina, caudad again to the abdomen, then dorsad (Fig. 45) along the wing bases to the metapleural suture (mtsu), which forms the dorso-cephalic border of the sclerite. At the caudo-ventral angles of the epimera there is a small triangular sclerite which is apparently cut off from the main portion of the epimeron. The primary suture follows the ventral margin of the deep fold which occurs at this point. The latero-ventral carina does not follow the ventral suture of the epimera all the way from the abdomen to the coxae, but, instead, follows a more direct line along the ventro-lateral margins of the thorax and diverges from the suture half-way from the abdomen to the coxae (Fig. 40). In the Coenagrionidae the sutures marking the ventral borders of the epimera are less distinct and do not follow quite the same course (Fig. 42).

Mesosternum and Metasternum.—The approximation of the coxae in the adults of Zygoptera has brought about profound changes in the mesosterna and metasterna.

Mesosternum (Figs. 40, 42; mst).—The key to the mesosternum lies in the invaginations of the furca (mfi) which mark the caudal limits of the sternum. In the Agrionidae the elevated parts of the sternum and sternellum form a distinct hour-glass figure with the furca on either side of the contracted portion. The margins of the sclerites are, however, parallel to the elevated portions, but are somewhat depressed. If the cephalo-lateral angles of the sternum are followed to the sides of the thorax they will be found to extend nearly as far dorsad as the dorsal margins of the mesinfraepisterna. The cephalo-lateral arms are expanded dorsad, and there are apparently several sclerites represented in the upper portions, possibly the remnants of the mesopresternum (Figs. 43, 45; pst). Along the lateral margins of the sternum cephalad of the furcae there are obscure invaginations which represent the prefurcae (mpf). These are difficult to see from the exterior unless the cuticle is cleared.

Mesosternellum (Figs. 40, 42; mstm).—The mesosternellum is similar in shape to the sternum except that the caudal margin is convex and heavily chitinized in some groups, notably the Agrionidae. The chitinized portions represent furcellae. From the caudal margin of the mesosternellum there extends a short, heavy, chitinous projection which sinks into the metathorax, and is lost from sight beneath the metasternella. This is a part of the metasternum (Figs. 40, 42).

Metasternum (Figs. 40, 42).—This sclerite is even more profoundly modified and distorted than the mesosternum. The metacoxae are almost contiguous and the muscles attached to the metasternum along the meson have drawn it well into the interior. The metafurcae can only be seen upon dissection of the thorax, and are to be found closely approximated along the ventro-meson. The prefurcae (mtpf) are a short distance cephalad of the furcae (mtfi). The presternum and sternum are fused, and the cephalo-lateral arms extend around the cephalic margins of the coxae and unite with the metinfraepisterna. The sternellum is represented in each sclerite mesad of the caudal half of the metacoxae, the caudal boundary being marked by two nearly contiguous chitinized spots on the meson (Figs. 40, 42).

Intersternum (Figs. 40, 42; ints).—The closing together of the metepimera has apparently resulted in the isolation of a portion of the sternum, near the abdomen. Comparisons with the thorax of Orthoptera and other orders show that this may be a portion of the abdomen, but in this case it is probably the cuticular membrane developed between the abdomen and thorax. The possibility that this sclerite represents an extra abdominal segment has already been discussed under the description of the nymphal thorax. The name intersternum has been applied to this area.

Postcoxal Area.—The area on the thoracic venter between the lateral carinae, caudad of the metacoxae and cephalad of the first abdominal sternum, is the postcoxal area.

Legs.—The legs are long and comparatively slender, and have long setae arranged regularly in rows (Fig. 35). They are not adapted for walking or running.

Coxae (Fig. 35, cx).—The coxae are large and globular, and there are prominent ridges on the lateral surfaces of the procoxae and the caudo-lateral surfaces of the mesocoxae and metacoxae.

Trochanters (Fig. 35, tr).—The trochanters are much smaller than the coxae and are divided into two short pieces in all families. The ventral length of both portions is much greater than the dorsal.

Femora (Fig. 35, fe).—The femora are long and cylindrical and without carinae except in a few genera. The ventral surface is provided with two rows of long black setae (fs), varying in number from three or four on the fore tibiae to as many as sixteen or seventeen on the hind tibiae.

Tibiae (Fig. 35, ti).—The tibiae are likewise long and slender and have a double row of setae on the ventral surface. In the fore tibiae of most species the setae of the cephalo-ventral row are conspicuously

flattened. The comb (tic) formed by these closely placed setae is probably used for cleansing the mouth-parts or the antennae. There is a great deal of variation in the length of the tibial setae and also in the number present in different subfamilies.

Tarsi.—The tarsi are always composed of three segments, the segments increasing in length from the proximal to the distal end (Fig. 35, ta). They are also provided with a double row of setae beneath, but these are never as long as the tibial or femoral setae.

Pretarsus.—The pretarsus (Fig. 19, pta) is beyond the end of the third tarsal segment and consists of a small shield-shaped piece on the ventral surface just beneath the bases of the claws. It extends back into the third segment, and in order to be seen best the claws should be pulled outward a little. There is also a small projection attached to the tip of this sclerite, but this is not homologous with the empodium of other insects. The ventral apical margin of the last segment of the tarsus is deeply emarginate on each side of the pretarsus.

Claws.—The claws are long and slender and the tips are always notched or bifid (Fig. 35, cw). The rays are seldom equal in length, and in some species the notch is far proximad of the apex.

Wings (Figs. 73, 74, 78, 81-90).—All Zygoptera have four similar membranous wings. In respect to venation and shape, the genus Hetaerina may be said to have the most primitive wing of any zygopteron found in Illinois (Figs. 74, 78). The position and course of the veins in the wings of this genus are as follows:—The costa, first longitudinal vein, forms the cephalic margin of the wing. The subcosta, second longitudinal vein, extends half the length of the wing from the base and ends abruptly in a short fork which marks an indentation in the margin. The two forks of the tip of this vein are in line with a heavy cross-vein caudad of it, and the brace formed by the alignment of the cross-vein and the subcostal forks is known as the nodus. The third longitudinal vein extends from base to apex of the wing and is composed of fused radius (R) and media (M) as far distad as the nodus and first radius (R_1) plus the second subcosta from nodus to apex. There are a number of cross-veins extending between costa and subcosta from the base of the wing to the nodus—the antenodal cross-veins. Between costa and radius, distad of the nodus and proximad of the stigma—the heavily chitinized spot near the apex of the wing—are the postnodal cross-veins. The remaining branches of the radius are united, forming the radial sector (Rs), and separate from the main trunk at the nodus. The course of the radial sector is difficult to follow because of its crossing one or two of the median veins. In Hetaerina the radial sector branches from the radius

at the nodus, crosses the first median vein, the first vein caudad of it, at the point where the second median vein separates from the first, follows the second vein for a short but indefinite distance, being fused with it, and then crosses over to the longitudinal vein caudad of the second media, and continues its course to the margin of the wing (Fig. 74). The point of separation of the radial sector from the second media is not evident, there being no oblique cross-vein as in the Anisoptera. The vein uniting the caudal end of the cross-vein over which the radial sector crosses, to the main radio-medial trunk is known as the bridge (seen in Lestes and Ischnura, Figs. 81, 85; br), and is secondary in origin. In Hetaerina the trachea of the bridge is fully as strongly developed in the nymph as any other of the main tracheal trunks. Such a feature would perhaps throw some doubt on the actual formation of the bridge in this suborder were it not for the strong comparative evidence present in the Anisoptera. The bridge reaches R-plus-M about half-way between the nodus and the base of the wing. About one-third of the distance from the base to the nodus is a strong, oblique cross-vein, the arculus (Figs. 81, 85; arc), from the middle of which two longitudinal veins arise. These veins are the third and fourth median veins (M_3 and M_4), respectively, the cephalic one being M_3. A short distance from the arculus there is another heavy cross-vein connecting M_4 with the longitudinal vein caudad of it. The cross-vein probably represents the medio-cubital cross-vein. The four-sided area enclosed by this vein, the portions of M_4 and the longitudinal vein caudad of it (the cubitus) and distad of the arculus, forms what is known as the quadrangle (qd), and corresponds to the cell first M_4. The cubitus extends from the base of the wing to the distal side of the quadrangle, where it forks and sends out two longitudinal branches caudo-laterad to the margin of the wing. The forks are Cu_1 and Cu_2, or first and second cubitus. The anal vein (A) consists of a single heavy trunk extending from the base of the wing and apparently connecting with the cubitus at the point where the latter forks. The different anal veins can not be traced because of numerous secondary cross-veins.

Many variations occur in the above wing-venation, but instead of a discussion of each in detail the reader is referred to figures 73 and 81–90 which show the types of venation occurring in the remaining genera of Zygoptera found in Illinois.

Abdomen (Figs. 91–100, 104).—The abdomen of all Zygoptera is cylindrical and composed of ten complete segments. In all of the segments the sterna are much reduced and hidden by the overlapping terga. The pleura are still more reduced, so that no portion of them

can be seen in the normal insect. If the body be softened and the lateral margin of the terga extended, the pleura appear as membrane between the margins of the terga and the sterna. In this membrane, near the cephalic-lateral margin of the first eight segments, the abdominal spiracles are found. The terga of all the segments are always large, are bent around from the dorsum onto the lateral aspect of the abdomen, and usually extend slightly onto the venter. A single tergum, then, has a dorsum and pleuron of its own. The terga are usually transversely rugose on the dorsum, and the lateral margins are always paler than the dorsum, and finely pilose. The apical margins of all except the last segment have elevated subapical chitinous rings which are frequently provided, especially in the terminal segments, with a number of short, heavy setae. The apical margin of the tenth segment may bear a long spine at the apex (Fig. 110), or the apical margin may have a long, subapical, blunt process (Figs. 166, 167), or it may be simply emarginate. The sterna are narrow transversely, with the exception of the first two and the last two, and are more or less hidden by the margins of the terga. The first sternum (Figs. 40, 42) is usually subtrapezoidal with the cephalic margin concave. The second sternum of the male is developed into an accessory copulatory apparatus which will be described later. In the female this sternum is similar to sterna three to eight and consists of an oblong plate of chitin, slightly wider cephalad, and having small ental projections at the cephalo-lateral angles. The eighth sternum of the female is divided into three sclerites (Figs. 109, 116), a single large proximal one and two small, sometimes obsolete, ones which are intimately connected with the first pair of gonapophyses. The ninth sternum (Figs. 109, 116) is greatly reduced in the female, being represented by narrow sclerites along the margins of the tergum extending from the proximal end to about the distal third or half of the segment. The ninth sternum of the male bears the genital opening, and on each side of this, and covering it, there is a more or less oval plate. These plates are known as the parameres (pa, Figs. 118, 121, 147, 165, 171, 172, 183). The tenth sternum is fused with the tergum on the lateral aspect.

Abdominal Appendages.—This term includes the accessory genitalia and anal appendages of the male, and the ovipositor of the female.

Accessory Genitalia (Figs. 33, 97, 98, 101, 105, 107, 108, 120, 122).—The accessory genitalia of the male are derived from the second and third sterna, and a portion sometimes from the second tergum. The sperm duct opens in the ninth sternum and spermatozoa are transferred to the accessory pouch or vesicle by doubling the abdomen upon

itself. The sternum of the second segment forms two heavily chitinized hamules (Fig. 33, hm) which serve as covering plates. The membranes immediately below these form a sheath for the penis (Fig. 33, ps). The latter is very heavily chitinized and is bent entad, extending to about the middle of the abdomen, and at the ental end are attached heavy muscles which operate the organ. The tip of the penis is largely membranous and flexible, and exhibits modifications which appear to be of specific value in classification, at least in some genera. The tip fits behind a heavy cephalic projection of the third sternum, the seminal vesicle, when not in use (Fig. 33, sv). Small knob-like projections may be seen extending ventrad from the lateral margins of the second tergum and just caudad of the hamules. These are frequently concealed in the Zygoptera but are large and conspicuous in the Anisoptera where they are known as the genital lobes (Fig. 33, gb). The cephalic third or less of the third sternum is elevated, heavily chitinized except at the tip, and extends some distance cephalad of the cephalic margin of the segment. In a few Anisoptera this part is reported as functioning as the penis, the parts already described for Zygoptera being unimportant.

The variations occurring in this organ throughout the suborder are marked and are in all cases of generic rank as diagnostic characters. In closely related specific groups, however, it can not be relied upon, and recourse must be had to the anal appendages.

Anal Appendages (Figs. 34, 38, 109; aas, aai).—At the caudal extremity of the abdomen of the male there are always four appendages; an upper dorsal pair, the superiors (aas), and a lower, the inferiors (aai). Of these, the upper is more often the longest, but it may be reduced and shorter than the ventral pair. The anus opens between and slightly dorsad of the bases of the mesal lobes of the ventral pair. The dorsal pair of appendages is frequently forcipate, and the tips are often contiguous and sometimes have between their bases a knob-like projection.

Ovipositor (Figs. 109–116).—The ovipositor of the female consists of three pairs of valves or gonapophyses. The ventral, mesal pair are slender and heavily chitinized, and are transversely ridged at the tip and usually provided with a saw-tooth edge. The cephalic pair of gonapophyses (oce) is derived from the eighth segment; the median pair (not shown in the figures) and the broad caudal pair (oca) from the ninth segment. The caudal pair of gonapophyses differ much in shape from the cephalic and median pairs. They are very broad at the base, somewhat contracted at the apex, and bear short, chitinized, curved subapical rods, the prostyles (prs). The ventral margins of

the caudal valves are always serrate.

Variations in the ovipositor of the female are seemingly of little importance in classification although there is enough difference in the apical sternites (sti_8) of the eighth segment alone to facilitate the separation of genera.

Life History and Habits

The metamorphosis of all Odonata is incomplete and the life history relates to the egg, nymph, and adult.

EGG

The eggs of Zygoptera are elongate and ovoidal, their length being much greater than their transverse diameter. In length they average about one millimeter; in diameter usually about one-fourth of this. They are inserted either above or below the surface of the water in the stems of plants. Lestes and related genera insert the eggs considerably above the level of the water, and several instances are recorded in which the plants suffer from excessive oviposition. Most of the Coenagrioninae oviposit beneath the water upon the submerged parts of plants. To accomplish this, the female with the male clinging to her alights on a projecting part of a plant and backs down into the water dragging the male with her. She often goes so far beneath the surface that both are completely submerged. Kellicott ('99: 24) observed the females of *Argia moesta putrida* descend into the water in this fashion; and I have frequently seen *Enallagma signatum* descend into the water to oviposit and, less frequently, *Ischnura verticalis* and *Enallagma antennatum*. It is probable that many more of the subfamily Coenagrioninae enter the water to find a suitable place for oviposition. The egg-laying habits of the Agrionidae have not been extensively studied; but Kennedy ('15: 339) reports that *Agrion aequabile* variety *yakima* deposits the eggs beneath the surface of the water upon willow roots, and is unaccompanied by the male. Needham also says that *Agrion maculatum* oviposits just beneath the surface of the water, but Wesenberg-Lund ('13) observed a European species depositing eggs above the water. In all cases the female was unaccompanied by the male.

The number of eggs laid by a single female has been but partially investigated, owing to the great difficulty of inducing the female to lay in captivity. A number of adults were dissected with a view to discovering the egg-laying capacities of the group. Several reared specimens which had no chance to deposit eggs were found to contain as many

as 1000 ova but only 60 or 70 of them were of normal size and considered mature. Another female, *Ischnura verticalis,* contained 203 mature ova, while a third teneral female of *Enallagma hageni* contained 290 mature ova. Calvert ('93) says that the average dragonfly probably lays between two and three hundred eggs, and this statement seems to coincide with that above.

The length of time spent in the egg stage is also imperfectly known. Lucas ('00: 18) reports that *Sympetrum striolatum* spends a month in this stage. Balfour-Browne ('09:256) says that eggs of *Ischnura elegans* and *Enallagma pulchellum,* laid at the beginning of August at East Norfolk, England, required from four to five weeks to develop. The temperature relations are not mentioned, but it is probable that this period varies to some extent. Needham ('03) calls attention to the fact that the eggs of Lestes, which are laid above water late in July, develop to a certain point, apparently ready to hatch, and await submergence before eclosion. The water does not reach them until late in fall; and this means that at least several months are spent in the egg stage. Brandt ('69) reported the development of *Agrion (Calopteryx) virgo* in three weeks during a hot summer.

In the final stages of embryonic development the head is directed towards the small end of the egg. This end is always nearest the cuticle of the plant, and the nymph consequently emerges head first.

NYMPH

Growth.—Immediately after hatching, the nymph is helpless and unable to move about actively. In this condition it is known as the pronymph (Balfour-Browne, '09:258). A few minutes afterward the skin of the pronymph splits and the true nymph escapes. During the second nymphal stage the nymph is a minute insect, hardly longer than the egg from which it hatched. The antennal segments are three and there are no wings or sexual appendages. From this stage the nymph grows and molts at intervals, the time between molts depending largely upon the temperature and the amount of food which it is able to capture. The antennae increase in number of segments until six are present, in which condition they remain until the last nymphal stage, when there are seven. The wings appear as ridges during the fourth stage, but the sexual appendages do not appear until the seventh stage, according to Balfour-Browne ('09). This seems to be contradicted by the rather frequent observance of nymphs without wing-cases and fairly well-developed appendages. There is great variation in the time between molts, due primarily to temperature. It often happens

that when nymphs are brought into the warm laboratory they molt within a few days. Balfour-Browne found surprising differences in the time between molts in nymphs kept at constant temperatures, so that it would seem probable that other factors enter into the problem besides temperature. He was able, however, to reduce the length of the stages by raising the temperature, and found that in some cases these lasted, in low temperatures, for 150 days, while in others they lasted only five days at higher temperatures. The number of molts varies from ten to fifteen in the Coenagrionidae, and the length of the nymphal life may range from 229–624 days (Balfour-Browne, '09).

Habitat.—In nature, the nymphs are most often found hiding among the weeds and rubbish along the margins of lakes, ponds, and streams. A few have been taken under rocks in swift currents, among them *Argia putrida* (Needham, '03) and *Argia tibialis.* The Agrionidae frequent the swifter currents, and seem to prefer these situations to any others. They are never found in stagnant ponds. Nymphs of Lestes, on the other hand, do not occur except in stagnant woodland pools, and are never taken along the banks of streams unless a stagnant condition is present. They prefer the shade, and hide among the broad-leaved types of small water-weeds, being rarely found among the narrow-leaved rushes and saw-grass. Riley ('12) says that the nymphs of Zygoptera react negatively to light from a projection lantern but that such a reaction is often inhibited by the habit of clinging to objects. He was unable, however, to obtain similar reactions to moderately strong daylight. Reactions to heat have not been studied, but the nymphs are able to withstand temperatures near the freezing-point and may be collected during the winter from beneath the ice. They readily succumb when the temperature of the water rises much above 70°F., but flourish well at 66.2°F. or 19°C. (Balfour-Browne, '09). Lestes is particularly sensitive to high temperatures, and when in captivity considerable care must be taken to keep the temperature low enough for them.

Food.—The food of the nymphs consists almost entirely of Crustacea, the larvae of nematocerous Diptera, such as mosquitoes and chironomids, and ephemerids. Very young nymphs have been known to thrive on Paramecium and other Protozoa. Of a large number of Lestes which were dissected, nearly all contained Daphnia and Cyclops, while the coenagrionines dissected contained many heads of chironomids and only occasionally small Crustacea. However, a single small *Ischnura verticalis* nymph contained eight specimens of Daphnia, and it seems highly probable that other insects are also taken when the normal food supply is scarce. Diatoms and other minute organisms

are frequently found in the alimentary tract, but this is due to the fact that other insects have been eaten which feed upon these organisms. The following is a list of the kinds of food known to be eaten by zygopterous nymphs.

Protozoa	Paramecium.
Crustacea	
Copepoda . . .	Cyclops.
Anemopoda . . .	Daphnia.
Arthropoda	
Arachnida . . .	Hydrachnidae (rare).
Insecta	Diptera—Chironomidae, Culicidae. Odonata—Zygoptera. Ephemerida—Ephemeridae.
Vertebrata	Very young fish.

Color Adaptations.—In almost any collection of live zygopterous nymphs, there will be found brown and green individuals of the same species. When collected from localities with abundant green vegetation, nearly all the nymphs will be green; when taken from situations where little green vegetation occurs, the nymphs are brown or dark in color. Furthermore, as has been observed in rearing specimens, green nymphs placed in a jar without green plants become brown after a few molts, and thus seem to be able to adapt themselves to the color of the surroundings. The color of the nymph, contrary to what might be expected, seems to have no influence upon the color of the adult.

Enemies.—The nymphs of Zygoptera are preyed upon by a number of enemies, the most formidable of which are fishes. Forbes ('88) reported that odonate nymphs formed ten to thirteen per cent. of the food of *Perca flavescens*—the common perch, *Aphredoderus sayanus* —the pirate perch, and *Pomoxis annularis*, the crappie; and twenty-five per cent. of the food of the grass pickerel, *Esox vermiculatus*. Riley ('12) says that *Lepomis gibbosus*, a common sunfish, and the yellow perch, *Perca flavescens*, commonly feed upon agrionid (coenagrionid) nymphs.

Among the predaceous aquatic Hemiptera, the genera Ranatra, Belostoma, and Notonecta, and probably others, feed upon the nymphs.

A mite, *Arrhenurus* sp., is a common external parasite of the nymph. At the time of emergence of the adult, the mite migrates from

the nymph to the adult and is carried about by the latter until it is nearly mature, when it escapes again into the water for the final stage. Another mite has been reported to feed upon the eggs of Anisoptera, but this statement has not been verified for the Zygoptera. Needham ('03) says that a large number of hymenopterous parasites prey on the eggs of Lestes, left exposed above the water-line, and he reared the following species: *Brachista pallida* Ashm., *Centrobia odonatae* Ashm., and *Polynema needhami* Ashm. Brandt ('69) also reports rearing *Polynema ovulorum* from the eggs of Agrion (Calopteryx) and says that as many as fifty per cent. of the eggs were sometimes destroyed by this parasite.

A fungus belonging to the Saprolegniales frequently attacks the nymphs, especially if enfeebled from any cause. Sometimes it becomes very difficult to rear specimens, and if the rearing-jars become infected nothing short of thorough sterilization will be of any avail. This fungus is related to the one attacking fish and causing great damage in hatcheries. It is also known to attack the larvae of Corydalis.

Emergence of Adult.—When the nymph has molted a stated number of times, somewhere between ten and fourteen, and has become full-grown, it crawls out of the water, dries its cuticle, which soon splits along the mid-dorsum of the thorax and head, and the adult emerges. The nymphs of Zygoptera usually seek the sunlight to transform and emerge early in the morning, the greater number being clear of the skin before eight o'clock. A much smaller number have been seen to emerge after six o'clock in the evening or late in the afternoon, but very few, if any, emerge during the heat of the day. The emergence follows a more or less definite schedule. When first out of the nymphal skin, the parts of the body are no larger than the parts of the foregoing nymph, and the insect is yellowish green in color. Great changes soon begin, including an elongation of the abdomen and wings as well as enlargement of other parts, and within an hour the insect is ready to take flight. At this time it may show mature coloration or the color may still be incompletely developed, and in this condition the adult is known as teneral. The teneral state may last for several days or longer, depending somewhat upon the amount of sunlight to which the insect is subjected, or there may be no further change after the power of flight is attained. *Enallagma exsulans*, *E. geminatum*, and the male of *Ischnura verticalis* are examples of species which apparently have no teneral state. *Enallagma carunculatum*, and *Ischnura verticalis*, female, are examples of species which apparently have a long teneral period. The change from

teneral to full adult coloration is a phenomenon which is not well understood. Just why the thoracic stripes of *Enallagma signatum,* for instance, should change from a pale but distinct blue to a bright orange in the course of development, while the stripes of the same region in *Lestes rectangularis* change from a dull brown to pale blue, is impossible to explain without a more thorough knowledge of the chemical nature of the pigments which undergo the changes.

The following observations were made upon the emergence of *Ischnura verticalis.* The rate of development is approximately similar to that of all Coenagrionidae. The rearing-jar was kept in the laboratory on the west side of the building and hence did not get the early morning sun. This accounts for the late emergence of the nymph.

9:30 A. M. The nymph crawled out upon the weeds within the jar and seemed about ready to emerge. The nymph when removed was dissatisfied and restless and tried to get a firm hold on something with its claws.

9:35. Body nearly dry.

9:45. The thorax suddenly splits and the insect rapidly emerges from the skin; color mostly light green and pale yellow; dorsal portion of the eyes dark; sides of the thorax darker.

9:50. Clear of the skin; wings 4 mm. in length, abdomen 10 mm.; general color becoming darker; greens becoming brown; wings increasing in length; insect restlessly moving about on the support.

9:55. Eyes plainly striped with brownish bands; abdomen 11 mm. in length, wings 4 mm.; wings suddenly elongating near the proximal end.

9:57. Wings 7 mm. in length.

10:00. Wings 8 mm., abdomen 12 mm. in length.

10:01. Wings 9 mm., abdomen 12 mm. in length.

10:03. Wings 11 mm., abdomen 12 mm.; wings pale light green, thorax and head brownish green; abdomen pale green at base, darker at apex.

10:06. Wings 13 mm., abdomen 12 mm.

10:07. Wings 15 mm., abdomen 12 mm.

10:09. Wings 15 mm., abdomen 13 mm.; abdomen suddenly elongating at the base.

10:14. Wings 15 mm., abdomen 15 mm.

10:18. Wings 15 mm., abdomen 15 mm.

10:20. Wings 15 mm., abdomen 16 mm.

10:24. Wings 16 mm., abdomen 20 mm.

10:28. Wings 16 mm., abdomen 24 mm.

10:30. Wings 16 mm., abdomen 24 mm. Thorax grayish green; abdominal segments two to six nearly transparent; wings becoming transparent; stigma faint, hardly noticeable.

10:35. No increase in length of the abdomen or wings; abdominal segments becoming dark near the sutures; stigma of the wings darker, now plainly noticeable; thorax olive-green; pronotum black.

10:40. First two segments of the abdomen dark green; segments three to six pale green, the apical segments the same as the proximal ones; thorax becoming steadily darker; first trial of the wings; the insect is nearly ready to fly.

10:45. Fully able to fly, but still delicate and without full adult coloration; no further increase in size of the abdomen or wings, but growing steadily darker in color and indications of permanent adult coloration becoming evident.

10:55. Stripes of the thorax very distinct, though no blue or other bright color has appeared; very active and using its wings frequently.

12:00 M. Not yet fully colored, the two apical segments of the abdomen beginning to show blue; the thoracic stripes of green not fully developed.

2:00 P. M. Postocular spots distinct; dorsum of abdominal segments eight and nine showing signs of the blue coloration.

3:00. Insect fully colored and perfectly developed in every way.

ADULT

Habitat.—The adult Zygoptera are most frequently encountered flying along the streams or about the lakes, ponds, or marshes in which the nymphs abound. Lestes is a frequenter of the thick woods near woodland marshes; Hetaerina and Argia are most commonly encountered near rapid streams, while the remainder of the Illinois representatives of the suborder may usually be found near small lakes, ponds, or sluggish streams.

Flight.—The flight is slow and uncertain, though frequently rapid enough to enable the insect to avoid the collector with surprising regularity. The vibration of the wings is much slower than that of the Anisoptera, and is more like that of a butterfly.

Mating Habits.—In summer, pairs of Zygoptera may be frequently found flying together. The male grasps the female just behind the prothorax by means of the anal appendages. The female then doubles the body beneath the body of the male bringing the ovipositor in contact with the accessory genitalia of the second abdomi-

nal segment of the male. After fertilization of the female the two continue to fly together and the female is refertilized at intervals during the egg-laying period. At the time of oviposition the two often remain together and the eggs are frequently laid while the pair are still in copula.

The time elapsing from emergence to egg-laying is not known with any certainty. The egg-laying period also, has been little studied, but it is thought to last for several weeks.

Food.—Many records have been made of the destruction of mosquitoes by Anisoptera, but no one seems to have observed or attempted to determine the feeding habits of the adults of Zygoptera. Dissection of a number of specimens revealed the fact that the Zygoptera prefer small Diptera to most other food. Many remains of nematocerous Diptera were found, as the following table will show, but very few remains of other insects.

Name	*Food eaten*	*Date of coll.*	*Locality*
1. *Hetaerina americana*, ♂	Hymenoptera (?)	Oct. —, 1915	Muncie, Ill.
2. *Ischnura verticalis*, ♀	Diptera—abundant remains	June 23, 1915	Havana, Ill.
3. *Ischnura verticalis*, ♂	Alimentary canal empty	June 23, 1915	Havana, Ill.
4. *Ischnura verticalis*, ♀	Many small Diptera	June 23, 1915	Havana, Ill.
5. *Argia apicalis*, ♂	Diptera—Nematocera	June —, 1915	Clear L., Ky.
6. *Enallagma civile*, ♂	Diptera	June 18, 1915	Urbana, Ill.
7. *Lestes vigilax*, ♂	Diptera—Nematocera	....	Bluffton, Ind.
8. *Enallagma hageni*, ♀	Diptera—Nematocera	July 18, 1915	Orono, Me.
9. *Enallagma antennatum*	Diptera—Nematocera	July 18, 1915	Urbana, Ill.
10. *Ischnura verticalis*	Large number of butterfly scales	July 13, 1915	Lake Villa, Ill.

The most common food of the adult apparently consists of small flies. No remnants were found which resembled mosquitoes, and the hymenopterous insect reported is questionably identified as such. The specimens of lepidopterous scales found in number ten were unmistakable, and it is, therefore, evident that other insects are sometimes eaten besides Diptera*. They have also been reported to eat aphids.

Enemies.—The adult Zygoptera are troubled by few enemies of any sort. Birds are perhaps the most important, but even these are not to be considered as serious enemies. Several species of hydrachnid mites have been found attached to the adult, the most common of which are species of Arrhenurus. The mites are often conspicuous on account of their orange or reddish color, and large numbers often attach themselves to a single individual. However, they seem to cause the insect but little inconvenience.

*Poulton ('06) reports that both Ephemeridae and Lepidoptera are sometimes eaten.

History of the Zygoptera

PALEONTOLOGY

The oldest records of insects which resembled Odonata are found in the upper Carboniferous. The wings are the only parts which are well preserved, but these are very different from the wings of living Odonata. The fossil species are termed Protodonata by Handlirsch and are thought to be connected with the still more ancient forms, the Paleodictyoptera, which are the most primitive of all fossil insects. The features which distinguish the Protodonata from the Paleodictyoptera and link them to the true Odonata include the fusion of the longitudinal veins at the base of the wing; the presence of numerous orderly arranged cross-veins; the appearance of interposed veins or sectors between the longitudinal veins; and, finally, the approximation of the wings themselves at the base. The protodonate wing, however, differs from that of true Odonata in the lack of stigma and nodus and in the supposed absence of that typical feature, the crossing of the radial sector over media. It is unfortunate that more of the bodies of these interesting forms have not been preserved, for it would be advantageous to know what types of head, thorax, and abdomen they possessed.

The next remains of importance are found in the Jurassic Lias of England and are much more closely related to living species than the Protodonata. They are classed as Odonata and divided into two suborders, the Anisozygoptera and Archizygoptera. There is a single living representative of the Anisozygoptera in Epiophlebia (Paleophlebia) of Japan, but the Archizygoptera have no living representative, and seem to be merely an offshoot from the Protodonata which apparently disappeared after a short stay in geological history. The archizygopterous wings show marked deviations from the original type of the Protodonata, and a very near approach to some of the zygopterous wings of today. The reduction in number of cells and cross-veins is characteristic of both ancient and modern forms, but the absence of the arculus and the separation of media and radius to the very base of the wing, distinguish the fossil species from any living forms. The Anisozygoptera have characters common to both Gomphidae and Agrionidae, the oldest fossils being perhaps more closely related to the Gomphidae. The wings have nodus and stigma, and the radial sector plainly crosses the median vein. The degree of obliquity of the quadrangle and the presence of many interposed sectors between the longitudinal veins place them with the Agrionidae. The head and the wings resemble those of Gomphidae in shape,

but the thorax and abdomen of the fossil suborder are variable and resemble both families to some degree.

The true Zygoptera make their appearance in the Jurassic period. The oldest of these, comprising the families Epallagidae and Steleopteridae, have been found in the lithographic quarries of Bavaria. The majority of species from this source belong to the Epallagidae and are fortunately in a good state of preservation. The wings are not petiolate, the nodus and stigma are present, the nodus being situated near the middle of the wing and the stigma being long and narrow. There is an oblique arculus and a more or less oblique triangle; the radial sector and the second median vein arise far distad of the nodus; and the costal field contains more than ten cross-veins proximad of the nodus. The abdomen is not greatly lengthened and the legs are also normal in this regard. In the Steleopteridae the wing is distinctly petiolate; there are about five antenodal cross-veins; and the veins M_3 and the radial sector arise proximad of the nodus. The arculus and quadrangle are similar to those of the Agrionidae (Calopterygidae). The family Steleopteridae is considered to be the forerunner of the Coenagrionidae.

The Tertiary deposits furnish us with the next oldest representatives of the group. True Zygoptera, Anisoptera, and a single family of Anisozygoptera have been found in the Florissant of Colorado and in the Tertiary deposits of Baden, Germany. Many of the species are referable to extant genera. More than eleven genera of Zygoptera have been found in these strata.

The first nymphs to appear in the geological record are described by Hagen from the Baltic amber and from the Tertiary of Rheinland and Baden, Germany. Many of these forms had caudal tracheal gills and were apparently true Zygoptera. Scudder ('90) has also figured and described a nymph from the Florissant which doubtless belongs to the Zygoptera.

The following tabular summary gives the characters which have been developed successively in the past, beginning with the family Dictyoneuridae of the Paleodictyoptera from which the Protodonata are thought to have been derived.

TABULAR SUMMARY

PALEODICTYOPTERA	PROTODONATA	ODONATA	
Dictyoneuridae	Meganeuridae Protagrionidae Paralogidae	Anisozygoptera Archizygoptera	Zygoptera Anisoptera
Wings moderately broad at base	Wings moderately broad at base	Wings broad or narrow at base	Wings broad or narrow at base.
Large number of irregular cells	Large number of polygonal cells	Reduction in the number of polygonal cells	Still greater reduction in number of polygonal cells in Zygoptera.
Subcosta ending in costa beyond the middle of the wing; not forked; no nodus	Subcosta ending about the middle of the wing; not forked; no nodus	Subcosta ending at middle of the wing; forked; nodus present	Subcosta often ending proximad of the middle; forked; nodus present.
	Cross-veins between costa and subcosta 22–50 or more	Antenodal cross-veins much reduced, usually more than two in number	Antenodal cross-veins often reduced to two in Zygoptera; more than two present in Anisoptera.
Radial sector not crossing media	Radial sector apparently not crossing media	Radial sector crossing media	Radial sector crossing media.
Radius and media not fused at base and no arculus formed	Radius and media fused but no arculus formed	Radius and media fused and arculus frequently formed	Radius and media fused and arculus always formed.
		Arculus near the base of the wing	Arculus further distad from the base.
Stigma absent	Stigma absent	Stigma sometimes present	Stigma only occasionally absent.
		Stigma not supported by oblique cross-veins or supplementary sectors	Stigma supported by oblique cross-veins, supplementary sectors, or both.
	M_2 arising proximad of end of subcosta	M_2 arising near the subnodus, often slightly proximad	M_2 arising at the subnodus or considerably beyond.
		Stigma cells numerous	Stigma cells few in Zygoptera.

TABULAR SUMMARY—*continued*

PALEODICTYOPTERA	PROTODONATA	ODONATA	
Dictyoneuridae	Meganeuridae Protagrionidae Paralogidae	Anisozygoptera Archizygoptera	Zygoptera Anisoptera
No quadrangle or triangles	No quadrangle or triangles	Quadrangle and sometimes triangles present	Quadrangle always present; triangles sometimes present.
Three simple anal veins present	Anal veins represented by a single vein	Anal veins represented by a single vein	Anal veins represented by a single vein.
Anal field not extensively developed	Anal field not extensively developed	Anal field often extended, but not braced by loop	Anal field extensively developed or reduced; when extended often braced by loop.
	Large numbers of rows of cells between all longitudinal veins, the rows extending far proximad	Decided reduction in number of rows and a decided retreat distad, leaving but few rows between the proximal portions	Still further reduction and retreat distad.
Head rounded; of considerable size	Not known	Head rounded and of considerable size	Head angular; often widened.
Not known	Not known	Eyes dichoptic in all families	Eyes dichoptic or holoptic.
Not known	Not known	Labium cleft	Labium cleft or entire.
Not known	Not known	Abdomen slender, occasionally swollen at tip; superiors leaf-like or forcipate	Abdomen slender, Zygoptera, or thickened, Anisoptera; superiors leaf-like, forcipate, or reduced to tubercles.
Not known	Not known	Inferior anal appendages separate	Inferior anals frequently united in Anisoptera.

ONTOGENY

The various parts of the body will now be considered with reference to their form during the different periods of development.

Head.—The compound eyes during the life of the embryo are small and dichoptic and situated on the lateral aspect of the head. After eclosion they become larger, are sometimes expanded dorsad, but never become holoptic until the adult stage. The embryonic antennae are composed of three segments, the second segment being longer than all the others together, and the third segment nothing more than a spur at the tip of the second. The increase in number of segments takes place by division of the second, which continues to divide until the antenna has seven segments in all. There is little, if any, variation in the diameter of the different segments of most nymphal antennae, but the proximal segments of a few are sometimes greatly developed and much larger than any of the distal ones. In the adult antennae, the apical segments are setiform and the number of segments varies from four to six. The labial palpi and the median lobe are without setae or fixed hooks. The cleft is usually obliterated after eclosion, but remains practically unchanged in the nymphs of some species. The labial palpi of the young nymph are soon after eclosion provided with fixed hooks, and the median lobe is furnished with rows of setae. The adults have no rows of labial setae, but these are scattered promiscuously over the surface. The condition of the mandibles and maxillae is not known for the embryonic stages, but the nymphal condition is much simpler than that of the adult. In this stage the mandible is not biramous except in a few cases. The adult mandible, however, is divided into two parts, one composed of a number of teeth and the other of several cutting edges forming a Z when viewed from the edge. The galea-lacinia of the nymphal maxilla is not as specialized as that of the adult, which bears a greater number of fixed hooks and setae.

Thorax.—The thorax of the embryo consists of three equal segments, each with a pair of appendages. Very little can be said of the sclerites in the embryonic stages, but the segments of the nymph are all about equal in size. The legs are widely separated and the invaginations of all furcae are usually prominent. The suture separating the proepimeron from the proepisternum is indistinct in the earlier nymphal stages, but becomes more distinct with age. In the mesothorax and metathorax, the interpleural suture is distinct in all zygopterous nymphs and in the adults of the family Agrionidae. In the Anisoptera it is indistinct in all stages. The infraepisterna and supraepisterna are separated by furrows in the nymph, but there are no definite sclerites formed until the adult stage. The mesonotum is

always divided in the nymph as in the adult, but seems to be simpler in structure in the nymph. The mesostigmal plates of Zygoptera are not developed until the adult stage, but the depressed area caudad of the mesoscutum in the Anisoptera is frequently present in the nymphal stages, especially in the Libellulidae. The nymph molts several times after eclosion before the rudiments of the wings appear as minute ridges on the dorsum of the mesothorax and metathorax. They develop subsequently like the wings of heterometabolous insects in general. As already noted, the crossing of the radial sector over the media can not be followed, and in only one genus, Lestes, is there any recognizable portion of the radial sector. The character of the tracheation of the wing-cases of several zygopterous nymphs is shown in Figures 14–17.

Abdomen.—Very little can be said of the abdomen except that in both the embryo and nymph the segments are about equal in length and more or less cylindrical. Reduction in size, lengthening of the segments, and flattening of the abdomen, together with the appearance of dorsal and lateral spines, seem to be the developmental tendencies in the nymph. The accessory genitalia of the adult show no signs of development until near the last nymphal stage, but the ovipositor of the female appears early, at least in the Zygoptera. This organ undergoes great modifications and specialization in the adult Zygoptera, but in the Anisoptera it is probably in the process of reduction and degeneration. The caudal tracheal gills of the Zygoptera are present in the embryo, and at hatching they appear as cylindrical, jointed, cerciform appendages. Brandt ('69) says that at a still earlier stage the lateral pair of gills are fused, but this observation has not been verified. There is also a pair of smaller cerci dorsolaterad of the lateral gills, making five caudal abdominal appendages in all. All five of these are represented in the Anisoptera by short cerciform appendages which are frequently triquetal and often sharply pointed at the apex. It is important to note that these appendages are never united in the nymphs of Anisoptera or in Zygoptera, but that in the adults of Anisoptera the ventral pair is sometimes fused. In all families of Zygoptera, the superior abdominal appendages, which replace the lateral gills, are greatly reduced, but in some Anisoptera, family Aeshnidae, the lateral appendages are replaced in the adult by long, lateral, superior appendages resembling gills. A fact which sheds light on the origin of the Odonata as a whole, is the presence of lateral abdominal gills in the genus Cora of Central America and Euphea of the Old World. The rectal gills of Anisoptera have been thought to originate in the forms having tracheae which anastomose on entering the walls of the rectum as in

most Agrionidae; but it is doubtful whether this fact is really important.

Some of the most interesting modifications of structure for comparison are found in the proventriculus. These were first investigated by Ris ('96), who discovered interesting correlations between the number of teeth and folds present and their supposed specialization in the different families. Conditions were simplest in the nymphs of Agrionidae; more highly specialized in the Coenagrionidae, Aeshnidae, Gomphidae, and Libellulidae. The adult structures were much more complicated than those of the nymphs of the same families.

The following table will suffice to show the important ontogenetic tendencies of living forms.

Table showing Ontogenetic Tendencies of Zygoptera as compared with Anisoptera

Egg		Nymph		Adult	
Anisoptera	Zygoptera	Anisoptera	Zygoptera	Anisoptera	Zygoptera
Eyes dichoptic	Eyes dichoptic	Eyes dichoptic	Eyes dichoptic	Eyes sometimes dichoptic, usually holoptic	Eyes dichoptic.
Labium cleft	Labium cleft	Labium sometimes slightly cleft, never deeply	Labium sometimes deeply cleft	Labium sometimes slightly cleft	Labium usually deeply cleft.
		Mandibles not divided at tip	Mandibles always divided at tip	Mandibles always divided at tip	Mandibles always divided at tip.
Labial palpus without fixed hooks	Labial palpus without fixed hooks	Labial palpus without fixed hooks	Labial palpus with two fixed hooks	Labial palpus with one fixed hook	Labial palpus with one fixed hook.
Median lobe without setae	Median lobe without setae	Median lobe with or without setae in rows	Median lobe with or without setae in rows	Median lobe with setae, but not in rows	Median lobe with setae, but not in rows.
Labial palpi without setae	Labial palpi without setae	Labial palpi with or without setae	Labial palpi with or without setae	Labial palpi without setae	Labial palpi without setae.
Antennae with three segments	Antennae with three segments	Antennae with 3–7 segments	Antennae with 3–7 segments	Antennae with 4–7 segments	Antennae with 4–7 segments.
		Epicranial suture traceable	Epicranial suture traceable	Epicranial suture traceable with difficulty	Epicranial suture traceable with difficulty.
		Furcae of metasternum often indistinct	Furcae of metasternum never indistinct	Furcae of metasternum concealed	Furcae of metasternum concealed.
		Interpleural suture indistinct	Interpleural suture never indistinct		

TABLE SHOWING ONTOGENETIC TENDENCIES OF ZYGOPTERA AS COMPARED WITH ANISOPTERA—*continued*

Egg		Nymph		Adult	
Anisoptera	Zygoptera	Anisoptera	Zygoptera	Anisoptera	Zygoptera
Mesepisterna usually separated	Mesepisterna adjacent or separated	Mesepisterna usually separated	Mesepisterna adjacent or separated	Mesepisterna adjacent and fused	Mesepisterna adjacent and fused.
		Wing-cases unequal in size	Wing-cases unequal in size	Wings unequal	Wings unequal.
		Trachea of radial sector crossing media	Trachea of radial sector not crossing media	Radial sector crossing media	Radial sector crossing media.
Abdomen cylindrical and about equal in diameter throughout; of the same diameter as the thorax		Venter flattened, abdomen much broader than thorax	Abdomen of the same diameter as the thorax	Abdomen widened at different points, usually of smaller diameter than thorax	Abdomen equal throughout; always of smaller diameter than thorax.
No tracheal gills but a long caudal projection	Tracheal gills present	No tracheal gills	Tracheal gills present	No tracheal gills	No tracheal gills.
		Ovipositor developed late or wanting	Ovipositor developed early	Ovipositor sometimes well developed; usually wanting	Ovipositor always well developed.
		Rectal gills present	Rectal gills absent	Rectal gills absent	Rectal gills absent.
		Folds of proventriculus: 4 large; 4 small	Folds: 4 large, 4 small; or 8 large, 8 small	Folds: 4 large, and 4 small	Folds: 8 large, and 8 small.

PHYLOGENETIC COMPARISON OF ZYGOPTERA AND ANISOPTERA

Several important theories and rules of procedure should be mentioned before undertaking a discussion of the suborders from a phylogenetic standpoint.

I.—*Ontogeny repeats phylogeny.* This is a well-recognized principle and is the foundation of much phylogenetic work.

II.—*All testimony should be corroborative* if properly understood; or in other words, there should be no real conflict in the phylogenetic evidence obtained from different sources.

III.—*The stem must be determined.* Before an agreement can be reached as to the phylogenetic status of any form, there must be agreement as to what constitutes specialization, and what generalized conditions. Suppose, for example, that within an order of insects there are species with two types of wings—one having numerous cross-veins and the other but few; which is the more specialized? It is possible for either type to have been derived from the other or both to have arisen from a third extinct form. One may have become specialized "by addition" and the other "by reduction". In this case it is evident that the stem must first be determined before the degree of specialization of either form can be stated with accuracy.

IV.—*All possible characters should be taken into account,* and a decision concerning the rank of the group should be based on a study of the whole organism. This method should be followed in view of the fact that the same degree of specialization in structure is not usually found simultaneously in different parts of the body, and it is always to be preferred to the method of determining specialization or generalization of a group of organisms by the study of a few characters.

V.—*The forces which produce modification in structure should be recognized if possible* and their effect upon structure determined.

In the following comparisons the various characters will be considered separately and, where possible, the stem form will be mentioned and the reasons given for so regarding it. For convenience, the division of the suborders into families as outlined by Handlirsch ('06-'08) and Muttkowski ('10) will be followed, the Zygoptera being divided into the Agrionidae and Coenagrionidae; the Anisoptera, into the Aeshnidae, Gomphidae, and Libellulidae.

Egg

1.—Eggs of the Odonata are of two types; one long and somewhat cylindrical in shape, the other ellipsoidal and short. The differences in shape are the result of different methods of oviposition. The ellipsoidal form would seem to be the more primitive, judging from a general knowledge of the eggs of various orders of insects. No definite proof of this can be given, but a comparison with the eggs of the Apterygota and the lower Arthropoda indicates that the ellipsoid is probably the stem type. This is, however, in direct contradiction to the argument found in the reduction of the ovipositor, since the species with specialized or reduced ovipositors lay ellipsoidal eggs. Disregarding the latter argument and considering the ellipsoi-

dal egg as the primitive type, the series from lowest to highest would be something like the following: Libellulidae, Gomphidae, Aeshnidae, Agrionidae, and Coenagrionidae.

Nymph

2.—The most striking differences in nymphal characters are found in the shape of the body. Zygoptera are without doubt nearest the primitive Campodea type, and Anisoptera show a marked deviation which is possibly due to the habits of life. This interpretation is supported by the embryonic stage, in which the body shape is essentially campodeiform in both suborders.

3.—The compound eyes of all forms are specialized, but the line of descent is not difficult to follow. The primitive type is found in the embryo, which has small circular eyes on the lateral aspects of the head. The nearest approach to this is found in the eyes of zygopterous nymphs; the farthest away from it, in the Anisoptera, where the eyes show a tendency to become dorsal in position. The cause of the modification is unknown, but may be due in part to their habits, the Anisoptera being mud-inhabiting to a large extent and needing eyes on the dorsum of the head. Another cause may possibly be found in the accelerated development of the greatly enlarged eyes of the adult. In respect to shape and position of the compound eyes, then, the Anisoptera should be regarded as the more highly specialized group.

4.—The antennae show important lines of development. The primitive antennae of the embryo consist of three segments, the second segment being the longest. A great lengthening of the first segment is the main line of specialization, and this occurs only in Zygoptera in the family Agrionidae. The antennae nearest the embryonic type are found in the Gomphidae; next in order are the Aeshnidae, then the Libellulidae, and, finally, the Coenagrionidae and the Agrionidae.

5.—The labium shows the more primitive condition in Zygoptera, where the median lobe is deeply cleft in the family Agrionidae. Gradations in complexity are found in a reduction in the depth of the cleft, and the line of specialization may be followed through the following series, beginning with the least specialized: Agrionidae, Coenagrionidae; Gomphidae, Aeshnidae and Libellulidae.

6.—Mental setae are lacking in the embryo and also in the nymphs of Aeshnidae, Gomphidae, Agrionidae, and a few Coenagrionidae. The cause of the production of mental setae is unknown. There

seems to be greater specialization in the shape of the labial palpi or lateral arms in the Coenagrionidae, notably the Lestinae, than in any other group. The simpler types are found in the Aeshnidae, Gomphidae, and Agrionidae, and a highly specialized form again in the Libellulidae.

7.—The condition of the maxillae and the mandibles in species existing prior to the present time can only be surmised, since there are no embryological or paleontological data on the subject. These appendages are so nearly alike in shape in the two suborders that no comparison can be profitably made.

8.—The primitive prothorax, according to both paleontological and embryological evidence, was a simple ring of the same size as the mesothorax and metathorax. Specialized conditions are found in the Anisoptera where, owing to the size of the head and the growth of the compound eyes, the cephalic part of the pronotum is depressed. The condition of the prothorax is probably primitive in Zygoptera. The sclerites are not as distinct in the Anisoptera as in the Zygoptera, indicating that obsolescense of the sutures has begun in this suborder.

9.—The next feature of note is found in the interpleural suture. Stages of disappearance occur in all Anisoptera, the suture being completely lost in the Libellulidae and perfectly distinct in all nymphs of Zygoptera. The cause of this modification is unknown, but it is probably due to the excessive development of the wing muscles within the thorax. In respect to this feature, then, the primitive forms are found in the Zygoptera; the specialized, in the Anisoptera.

10.—Another modification is found in the disappearance in the Libellulidae of the metafurcal invaginations. The primitive condition or stem form is unknown, as is also the cause of the disappearance. It is probable, however, that the type with distinct invaginations is the more generalized, which places the Zygoptera, the Aeshnidae, and the Gomphidae much below the Libellulidae in position.

11.—In the shape of the wing-pads, the Anisoptera show more conformity to the generalized types occurring in Plecoptera and Orthoptera than do the Zygoptera; and they must be regarded as generalized in this respect.

12.—The simplest abdomen, judging from embryological studies, is a cylindrical portion of about the same diameter as the thorax. The abdomen is much modified in all Anisoptera, where it is enlarged and the venter flattened. The Zygoptera are generalized in this respect, and a series showing progressive specialization in this single feature would be as follows: Agrionidae, Coenagrionidae, Aeshnidae, Gomphidae, Libellulidae.

13.—The caudal tracheal gills of Zygoptera must be considered a simple or stem character. This view is supported by much evidence from embryological studies and the presence of one or two living forms in which the gills are decidedly cerciform and cylindrical. The modification into flat plates is undoubtedly specialization, but the reduction of the abdominal appendages in the Anisoptera indicates further specialization of a different kind. Changes in shape of the zygopterous appendages are probably due to a change from terrestrial to aquatic habits very early in the history of the group. If we consider that the anisopterous appendage has been derived by progressive reduction, the following should be the order of development: cylindrical cerci, flattened cerci, and reduction of cerci to short appendages similar to those in all Anisoptera. If, however, the gills be regarded as derived from shorter caudal appendages, the Anisoptera have the primitive types and the Zygoptera are highly specialized in their elongate, flattened appendages. The presence of cylindrical cerci as a primitive character seems to have the greatest amount of embryological evidence to support it.

14.—The abdominal gills of Cora and Euphea of the Zygoptera also afford comparative evidence as to the age of this suborder. Here there are remnants of lateral, cylindrical gills on the abdominal segments. There seem to be embryological data sufficient to prove that these lateral gills represent the appendages of forms more primitive even than the Insecta.

15.—The oldest fossil Odonata showing ovipositors had the characters of both Zygoptera and Anisoptera, and it is probable that the stem forms had true ovipositors. The simplest type of ovipositor among living Odonata is found in the nymphs of Zygoptera and consists of a number of similar valves. The reason for the reduction of the ovipositor in the adults of Anisoptera lies in the acquisition of the aquatic habit and the consequent difficulty of depositing eggs in plant tissue. It is reported that some Zygoptera do not insert the egg in the plant but merely press it against the plant and allow it to drop to the bottom; and this appears to be a transition stage from the endophytic to the exophytic method of oviposition. Reduction of the gonapophyses, then, means specialization, and the order would be—Zygoptera, generalized; Anisoptera, specialized.

Adult

16.—So many different lines of specialization seem to have taken place in the development of the head capsule of the adult that it is

almost impossible to arrive at any conclusion as to its simplicity or complexity. Suffice it to say that paleontological and embryological data prove that there are primitive types in both Zygoptera and Anisoptera. In the holoptic condition of the compound eyes, however, there is a more definite character. As already stated, the primitive type is dichoptic; and beginning with this condition, which we find most closely approximated in the Zygoptera, there are all degrees of dichoptic and holoptic states. The cause of the modification is probably due, in the adult, to the increased power of vision made necessary by the greatly increased powers of flight and the fact that the insect captures its prey while on the wing. An excellent series of specializations is to be had in the following families, the Zygoptera being the more generalized: Agrionidae, Coenagrionidae; Gomphidae, Aeshnidae, and Libellulidae.

17.—The antennae, as already noted, show marked reduction in size from those of the nymphs. The nearest approaches to the primitive. seven-segmented condition are found in the Libellulidae and some of the Aeshnidae, where six segments are often encountered. Most representatives of the remaining families have the segments quite consistently reduced to four. The adults of the Agrionidae have the most highly specialized antennae; and in a series showing increasing specialization the Libellulidae would be the more generalized. The following is such a series based upon antennal structure: Libellulidae, Aeshnidae, Gomphidae, Coenagrionidae, and Agrionidae.

18.—The front shows great deviation from the simpler forms in the majority of the Anisoptera, and the mound-like elevation of this part is characteristic of most families of this suborder.

19.—The mandibles of the adult have apparently undergone no modification of importance in the different families. They are so nearly alike in all groups that a comparison will not be attempted.

20.—The maxillae of the adult have likewise undergone little modification in the different families, but the form nearest the primitive type present in Plecoptera nymphs is found in the Gomphidae.

21.—The labium shows the same deviations from the primitive condition as were described for the nymph. Looking upon the depth of the median cleft as a measure of generalization, the Agrionidae would be considered as the more generalized. Next in order are the Coenagrionidae and, following these, the Aeshnidae, Gomphidae, and Libellulidae. The labial palpi retain about the same degree of specialization that occurs in the nymphs; and the same sequence of family specialization as has been described for the nymphs is present in the adults.

22.—As regards the form of the microthorax, no stem can be determined, but it is probable that there has been much more specialization in the Anisoptera than in the Zygoptera.

23.—The degree of complexity of the prothorax as a whole is difficult to determine. Many sexual modifications occur in the adults which must be considered as secondary characters having little bearing on phylogeny. The distinctness of the propleural suture, however, is of some value. In Zygoptera, this suture is most distinct in the Coenagrionidae (Lestinae) and is moderately so in the Agrionidae. In the Anisoptera it is most distinct in the Aeshnidae, but is as a rule indistinct in other families. According to this character the Zygoptera seem to be generalized; the Anisoptera specialized.

24.—In the mesothorax and metathorax the most important feature, aside from the wing structure, is to be found in the interpleural suture. As already mentioned, this suture shows no sign of disappearance in any of the nymphs of Zygoptera, and still remains undiminished in distinctness in the adults of the family Agrionidae. In the Coenagrionidae, however, the interpleural suture becomes obsolete in great measure. In both nymphs and adults of Anisoptera, it is indistinct. The degree of its distinctness is therefore an excellent character for determining the degree of specialization or generalization of the species and consideration of this fact alone leads to the conclusion that the Zygoptera are the more generalized.

25.—The varying degrees of approximation of the mesepisterna and the metepimera indicate an entirely different line of development from that shown in 24. The primitive condition is one in which the two mesepisterna and metepimera are separated by considerable intervals, as has been shown for the nymphs. The approximation of the metepimera on the ventro-meson is a much later development and does not appear until the adult stage. Nevertheless, nearly the same line of specialization occurs as in the former case, the simplest conditions being found in the Aeshnidae and the Agrionidae, the more complex in the Gomphidae, Libellulidae, and Coenagrionidae.

26.—The development of the mesothoracic spiracles indicates that the Libellulidae, again, are the most specialized, with the Agrionidae and Aeshnidae at the bottom of the series. The size of the spiracles in Libellulidae and the degree of their approximation on the dorsomeson warrant this assumption, the primitive types being small in size and rather widely separated, as in Zygoptera and some Aeshnidae.

27.—A line of specialization is found in the length of the thorax caudad of the metacoxae. In this the Coenagrionidae and Agrionidae are decidedly the more specialized.

28.—More use has been made of the wings and wing venation in following out genealogical development than of any other single portion of the body of the dragon-fly. The evidence is conflicting in many respects, and in coming to conclusions all characters must be taken into account. The most noticeable feature of the wing venation is the crossing of the longitudinal veins Rs and M. This condition is so unique that it was doubted or denied for a long time, and not until it was traced from its beginning in the tracheae of the nymph was it generally accepted as true. Many of the changes in the wing venation may be considered as the result of stress on particular portions of the wing surface. The development has followed two lines of specialization; one of them a reductive process, exemplified in the Zygoptera, the other additive, exemplified in the acquisition of important wing-braces in the wings of Anisoptera.

The main points regarding the specialization of the odonate wing are stated in the following tabulation.

Generalized conditions	*Developmental tendencies*	Supported by paleontology	Supported by ontogeny
1. Wings of equal size and venation.	Wings of unequal size and venation.	Yes	Yes
2. Wings not petiolate.	Wings petiolate.	Yes	Yes
3. Nodus not retracted; near the middle.	Retraction of the nodus towards the base.	Yes	Yes
4. No reduction in number of cross-veins.	General reduction in number of cross-veins.	Yes	?
5. Arculus near the base of the wing.	Retreat of the arculus distad from base.	Yes	Yes
6. No reduction in the number of antenodals.	Reduction in number of antenodal cross-veins.	Yes	?
7. No reduction in the number of postnodals.	Reduction in number of postnodal cross-veins.	Yes	?
8. Rs traceable throughout its course.	Rs not traceable throughout its course.	No	Yes
9. M_2 not arising distad of the nodus.	M_2 arising distad of the nodus.	Yes	?
10. Rs separating from M_2 near the nodus.	Rs separating from M_2 distad of the nodus.	Yes	?

	Generalized conditions	*Developmental tendencies*	Supported by paleontology	Supported by ontogeny
11.	Quadrangle triangular.	Quadrangle rectangular.	Yes	No
12.	M_3 and M_4 not uniting distad of the arculus.	M_3 and M_4 uniting distad of the arculus.	Yes	Yes
13.	Media at the top of the arculus.	Media descending the arculus.	Yes	Yes
14.	No development of the anal loop.	Development of the anal loop.	Yes	Yes
15.	No matching of the transverse cross-veins.	Matching of the transverse cross-veins.	Yes	Yes
16.	Pentagonal cells numerous.	Reduction in number of pentagonal cells.	Yes	Yes
17.	Little reduction in the number of rows of cells and little retreat distad.	Reduction in the number of rows of cross-veins between all longitudinal veins and retreat distad of the rows.	Yes	Yes
18.	Nodus and arculus not approximated.	Approximation of the nodus and arculus.	Yes	Yes
19.	Stigma long.	Stigma short.	Yes	Yes
20.	Stigma sometimes absent.	Stigma always present.	Yes	Yes

The different families are specialized in the characters listed under the figures following them:—

Coenagrionidae.—2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20.

Agrionidae.—11, 15, 16.

Aeshnide.—2, 5, 11.

Gomphidae.—1, 5, 7, 11.

Libellulidae.—1, 12, 13, 14.

From the above it will be seen that in wing venation the family Coenagrionidae is by far the most highly specialized, while the Agrionidae, Aeshnidae, and Gomphidae are about equally specialized, and the Libellulidae are intermediate in position.

29.—The primitive abdomen consisted of a cylindrical portion of the same diameter as the thorax; and the same is now essentially true of the nymphs of Zygoptera. In the adults, however, the diameter

of the segments has been reduced as compared with that of the thorax. In the Anisoptera there are other modifications besides the reduction in diameter. Here, the abdomen is sometimes triangular in cross-section, and different portions of the abdomen of the same species have different diameters. Considering shape alone, the following line of development may be recognized, beginning with the more generalized: Agrionidae, Coenagrionidae, Aeshnidae, Libellulidae, and Gomphidae. This order of specialization is followed throughout in the abdomen.

30.—The approximation of the terga on the ventro-meson, is a mark of specialization most frequently found in the Anisoptera, as is also the appearance of the secondary ridges on the terga.

31.—The anal appendages of the abdomen are interesting, and the line of specialization indicated by them seems to coincide in general with that already outlined for the suborders in 29 and 30. The series has already been given for the two groups in paragraph 13. Within the Anisoptera, two different lines are found, both probably representing specialization. In one of these the inferiors are fused, as in the Libellulidae; in the other the superiors are enlarged and expanded, as in the Aeshnidae. In the Zygoptera the forcipate appendages of the Agrionidae probably represent the most primitive forms, and the short and frequently greatly modified appendages of the Coenagrionidae, the more highly specialized.

32.—Accessory male genitalia of the second segment are important. The statement that this organ has been derived from the sexual organs of the progoneates is substantiated by the reported connection of the proximal end of the penis with the visceral cavity. This occurs in Zygoptera and seems not to have been observed in the Anisoptera, the connection supposedly having been lost through specialization. Further specialization has been suggested in the tracheation of the appendages, which occurs in some Anisoptera according to Backhoff ('10) but not in Zygoptera. Other differences indicating specialization in Anisoptera are to be noted in the segmentation of the penis and in the position and connection of the seminal vesicle with the latter. The structure of the hamules and the genital lobes, and of the portions of the genitalia arising from the third abdominal segment, seems to be simpler in the Zygoptera and not so much reduced or changed from the original plan of the sterna of these segments. The tip of the intromittent organ is much simpler in structure in the families of Zygoptera.

33.—As mentioned in paragraph 15, the presence of the ovipositor in the early stages of the nymphs of Zygoptera and its absence in the nymphs of Anisoptera suggest that the anisopterous appendages have

been reduced from a primitive form similar to that of Zygoptera. This, together with the evidence furnished by extinct species where adults with wing venation similar to that of the Anisoptera had ovipositors, proves fairly conclusively that the extant species without ovipositors have undergone specialization by reduction.

34.—One of the most complete lines of specialization has been determined by Ris ('96) for the structure of the proventriculus. He found what he considered a primitive condition in the Zygoptera (Agrionidae) in which there are sixteen internal folds. Specialization takes place by reduction, and there are eight folds in the Lestinae, four in Gomphus and Aeshna, and none in Libellulidae, there being instead four large symmetrical teeth.

35.—Specialization among the Anisoptera seems to be still further indicated by the habits of the group, especially their habits of migration. The mere fact of migration is not important; but the method of flying in companies and particularly of so flying that there are regularly spaced intervals between the individuals is something which, if true, is unique in this order and in the class Insecta.

Considering the preceding characters as a whole, it will be found that there are two orders of specialization which apparently proceed in opposite directions. One of these begins with the Agrionidae of the suborder Zygoptera and ends with the Libellulidae of the Anisoptera; and the other begins with the Libellulidae and ends with the Agrionidae. The characters mentioned in the various paragraphs will now be assembled for a comparison of the number of generalized features in each family. The families are listed below, and are usually or frequently generalized in the characters discussed in the paragraphs the numbers of which are placed opposite.

Agrionidae.—2, 3, 5, 6, 8, 9, 10, 12, 13, 14, 15, 16, 18, 21, 22, 23, 24, 25, 28, 29, 30, 31, 32, 33, 34, 35.

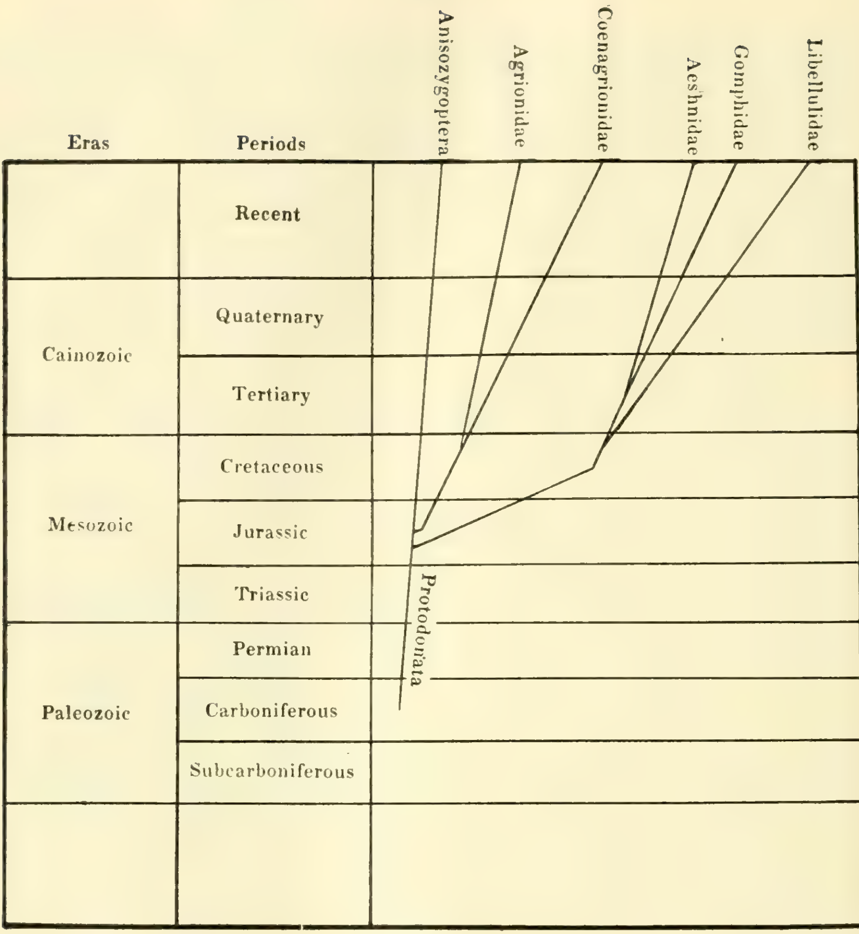
Coenagrionidae.—2, 3, 5, 8, 9, 10, 12, 13, 14, 15, 16, 18, 21, 22, 23, 24, 26, 29, 30, 31, 32, 33, 34, 35.

Aeshnidae.—1, 4, 6, 10, 11, 15, 17, 25, 27, 28.

Gomphidae.—1, 4, 6, 10, 11, 17, 20, 27, 28.

Libellulidae.—1, 11, 17, 27, 28.

From this it will be seen that the most generalized family is the Agrionidae. The evidence is such that it can not be doubted, and it points to some form of the Agrionidae or related family as the stem type. The following genealogical tree, based partly on Handlirsch ('06–'08), has been constructed after taking into account all existing evidence. Distance to the right indicates specialization; vertical distance, time.



Classification

Some of the more important features used in the classification of the nymphs of Zygoptera include the characters of the labium and antennae, the nature of the caudal gills, and the armature of the lateral keels. The classification of the adults depends upon the wing venation and the anal appendages of the male, as well as on such characters as the mesostigmal plates of the female, color, and the like.

The number of species occurring, or probably occurring, within the state is forty-two, as follows. Those without asterisk have been taken in adjoining states by other collectors; those with one have

been reported from Illinois; and those with two have been collected by the writer or seen in collections actually made within the state.

**_Agrion aequabile_ (Say)
**_Agrion maculatum_ Beauvais
**_Hetaerina americana_ (Fabricius)
**_Hetaerina titia_ (Drury)
*_Lestes congener_ Hagen
*_Lestes disjunctus_ Selys
Lestes eurinus Say
**_Lestes forcipatus_ Rambur
*_Lestes inaequalis_ Walsh
**_Lestes rectangularis Say_
**_Lestes uncatus_ Kirby
**_Lestes unguiculatus_ Hagen
**_Lestes vigilax_ Hagen
**_Argia apicalis_ (Say)
Argia fumipennis (Burmeister)
**_Argia moesta putrida_ (Hagen)
*_Argia sedula_ (Hagen)
**_Argia tibialis_ (Rambur)
**_Argia violacea_ (Hagen)
**_Enallagma antennatum_ (Say)
*_Enallagma aspersum_ (Hagen)
**_Enallagma calverti_ Morse
**_Enallagma carunculatum_ Morse
**_Enallagma civile_ (Hagen)
Enallagma cyathigerum (Charpentier)
Enallagma divagans Selys
Enallagma doubledayi Selys
**_Enallagma ebrium_ (Hagen)
**_Enallagma exsulans_ (Hagen)
**_Enallagma geminatum_ Kellicott
**_Enallagma hageni_ (Walsh)
Enallagma piscinarium Williamson
**_Enallagma pollutum_ (Hagen)
**_Enallagma signatum_ (Hagen)
**_Enallagma traviatum_ Selys
**_Nehalennia irene_ Hagen
**_Amphiagrion saucium_ (Burmeister)
**_Chromagrion conditum_ (Hagen)
Ischnura kellicotti Williamson
**_Ischnura posita_ (Hagen)
**_Ischnura verticalis_ (Say)
**_Anomalagrion hastatum_ (Say)

The division of the suborder into families and the arrangement of genera followed by Muttkowski ('10) have been adopted and are herewith reproduced, including only the genera that occur in Illinois.

Family	_Subfamily_	_Genus_
Agrionidae	Agrioninae	Agrion Hetaerina
Coenagrionidae	Lestinae	Lestes
	Coenagrioninae	Argia Enallagma Nehalennia Amphiagrion Chromagrion Ischnura Anomalagrion

In the following descriptions "length" refers to the length of the body without appendages, and does not include caudal gills, anal appendages, or antennae. In the color descriptions, where suitable material was at hand, the colors were matched with colors given by Ridgway in his "Color Standards and Color Nomenclature" ('12), and the names of colors which appear in parentheses are from that author.

Family *AGRIONIDAE*

The nymphs of this family are easily distinguished from those of the Coenagrionidae. The three-sided gills, the deeply cleft median lobe of the labium, the large basal segments of the antennae, the unequal length of the gills, and the heavy and sprawling appearance of the legs are characteristic.

The adults are, as a rule, bright or strikingly colored, such colors as metallic green and carmine being common. A large number of antenodal cross-veins between costa and subcosta and the presence of a distinct interpleural suture are also diagnostic.*

Subfamily AGRIONINAE

Key to Genera

NYMPHS

a. Median cleft of median lobe of labium extending proximad of the articulations of the labial palpi; body color usually dark. . . . . *Agrion.*

aa. Median cleft not extending proximad of the articulations of the labial palpi; body color usually light. . . . . *Hetaerina.*

ADULTS

a. Wings with the basilar space, cell first M, without cross-veins; metapleural suture only with a pale stripe. . . . . *Agrion.*

aa. Wings with a basilar space provided with cross-veins; mesopleural, interpleural, and metapleural sutures with pale stripes. . . . *Hetaerina.*

Genus Agrion Fabricius

In the nymph the median lobe of the mentum is provided with a deep cleft which extends far proximad of the articulations of the

*Only one genus in this family is known in which the interpleural suture is not well developed, and since that genus does not occur in the United States, this character has been included in the family description.

labial palpi. The caudal gills are dark, with a light transverse band about the middle of their length. The caudo-lateral margins of the head are elevated to form a short, sharp tubercle. The nymph of but one species has been available, and a study of this, together with a comparison with Hetaerina, has afforded possible generic characters.

The adults are uniform in color, usually dark metallic green or blue, and black, and the wings are broad, with a large number of cross-veins, the basilar space, however, being free from them. The legs are provided with a double row of ventral setae which are usually several times longer than the spaces between their bases.

Key to Species

a. Intersternum metallic green; wings of male smoky only on the apical third; female with a sharp spine on the dorso-apical margin of the tenth abdominal segment; latero-ventral margins of thorax pale..... .... *aequabile.*

aa. Intersternum entirely black; wings of male wholly dark; female with only a short blunt projection on the dorso-apical margin of segment ten; latero-ventral margins of thorax dark.............. *maculatum.*

Agrion aequabile (Say)

Nymph.—The nymph of *aequabile* has not been available for study, but this species and its variety *yakima* have been described by Needham ('03: 223,224) and Kennedy ('15: 338). It seems to be nearly identical with *maculatum.* The length of the basal segment of the antenna is used by Needham for its separation from *maculatum,* but this character can not be used for the separation of the variety *yakima.* The length is somewhat greater and the gills somewhat longer than those of *maculatum,* but this character also is of doubtful importance, and further study of the two species should be made to determine the essential differences.

Adult; Male.—Color, metallic green and blue.

Head: mouth-parts black, median lobe of the labium triangular in outline, basal segment of the palpus very broad, distal segment small, cylindrical, longer than the fixed hook of the first; palpiger about one-third the length of the first segment; antennae entirely black; clypeus and labrum black; the front and genae metallic green and thinly clothed with dark hairs.

Thorax metallic green, black and green below; pronotum with the caudal margin entire, the caudal lobe convex and projecting caudo-dorsad; proepimeron distinct; cephalic portion of the prescutum large,

subtriangular, and depressed; paraptera subtriangular, each half with the caudal margin sinuate and slightly emarginate on the lateral half; intersternum green; legs entirely black, the ventral setae much longer than the distances between their bases, the setae of the front femora twelve to fourteen in each row; wings transparent, except the apical third (Fig. 73), which is smoky, about one-third as broad as long, slightly narrower than the wings of *A. maculatum;* stigma wanting, antenodals of the front wing thirty-two.

Abdomen green and blue; sternum of segment ten and the apical third of sternum nine buff-colored; anal appendages (Fig. 117) mostly black, the superiors wholly black, long and curved, tuberculate on the lateral surfaces, and slightly emarginate on the mesal margins at the middle; inferiors black at the apex, paler at the base, nearly as long as the superiors, and provided with a minute apical point directed mesad; parameres of the ninth segment small (Fig. 118).

Female.—Color, metallic green.

Head: proximal half of the second antennal segment with a pale lateral spot; labrum buff-colored on each side, and with a median hourglass-shaped black mark; exposed portions of the mouth-parts, including the mandibles and their trochantins, buff.

Thorax: latero-ventral margins pale, including the cephaloventral margins of the mesepisternum, caudal half of the mesinfraepisternum, a stripe along the metapleural suture extending more than half-way from the cephalic margin to the wing bases, and the ventral and cephalic margins of the metepimera; intersternum green; wings slightly smoky, but not darker on the apical third, stigma present, white.

Abdomen metallic green and black, the apical portion dull and paler below; tergum of segment ten with a prominent mesal ridge which is produced into a long spine at the apex (Fig. 110); anal appendages consisting of conical superiors, double the length of the blunt inferiors; ovipositor reaching to the middle of the tenth segment, the prostyles extending to its apex (Fig. 110).

Measurements

Length, ♂ ....49 mm.
Length, ♀ ....44 mm.
Length of abdomen, ♂ ....38 mm.
Length of abdomen, ♀ ....34 mm.
Length of hind wings, ♂ ....32 mm.
Length of hind wings, ♀ ....29 mm.
Width of hind wings, ♂ .... 9 mm.
Width of hind wings, ♀ ....8 mm.

The species is apparently rare in Illinois though reported from this state by Williamson ('00). The above description was made from three specimens in the collection of the Illinois State Laboratory of Natural History, two of which bear the label "Mass.". I have not seen the species within the state.

Agrion maculatum Beauvais

Nymph.—Color, dark brown.

Head pentagonal, little contracted behind the eyes; eyes black, a black stripe nearly the width of the eye extending to the caudal margin of the head, and another stripe extending from the antennal fossae to the eyes; proximal segment of the antennae thick, about as long as the head, and usually slightly longer than all the remaining segments together; labium with the median lobe deeply cleft, the cleft extending proximad of the articulations of the labial palpi (Fig. 8); proximal segment of the palpus with three immovable end-hooks and two small setae near the base of the distal segment of the palpus.

Thorax: prothorax with a broad dark line on each lateral margin which is continuous with the dark line on the side of the head; legs slender, the femora with a whitish band on the apical third, with a narrower brownish band proximad of the white one, and a distal brownish band extending to the apex of the segment; tibiae without heavy setae; tarsi short; wing-cases broad and extending in full-grown nymphs as far as the fourth abdominal segment.

Abdomen subcylindrical, dark, and without distinct lateral keels; apical margins of the terga with about four dark spots on the dorsum; lateral tracheal gills three-sided, somewhat blunt, with a white transverse band near the middle of their length; median gill flat, shorter, with a similar cross-band at the middle and another faint band beyond; marginal setae of the median gill long and slender, extending entirely around the gill.

Measurements

Length	20 mm.
Length of abdomen	15 mm.
Length of lateral gills	10–12 mm.
Length of metathoracic wing-cases	6 mm.
Length of median lobe	4.5 mm.
Width of median lobe	1.3–3 mm.

Adult; Male.—Color, metallic green or blue.

Head green; labium black, the median lobe subtriangular in outline, the cleft extending slightly less than half the distance from apex

to base; proximal segment of the labial palpus broad, black, the palpiger short, about one-half the length of the first segment measured from the point of articulation to the base of the second segment, the fixed hook nearly as long as the distal segment of the palpus; antennae black; clypeus and labrum metallic green or black; front, together with the clypeus and labrum, thinly clothed with black setae; eyes black or slate-colored.

Thorax green above, black below; pronotum with the caudal margins entire, the caudal lobe convex and projecting caudad and dorsad; proepimeron distinct; cephalic portion of the mesoprescutum subtriangular, depressed; dorsal carina distinct, black; paraptera subquadrangular, the caudal margins emarginate on the lateral third; metepimera broader adjacent to the wings; ventral portion of the metepimera and the intersternum wholly black and subshining; legs black, the setae also black and longer than the space between their bases; anterior femoral setae fourteen or fifteen on each side; tarsi black; wings very dark, almost opaque, and about one-third as wide as long; stigma wanting; antenodal cross-veins twenty-seven.

Abdomen nearly cylindrical, glabrous and faintly striated transversely; superior anal appendages long and black, the lateral surfaces tuberculate, the mesal surfaces emarginate at about the middle; inferiors nearly as long as the superiors, straight and with a small apical hook directed mesad (Figs. 139,139a).

Female.—Color, metallic green.

Head not essentially different from that of the male.

Thorax: wings pale brown, darker at the tips, transparent; stigma present, white; antenodal cross-veins 23 to 24.

Abdomen much shorter than that of the male; anal appendages consisting of conical superiors more than twice the length of the blunt inferiors; ovipositor (Fig. 109) with broad lateral valves reaching about to the apex of segment ten, the prostyles rod-like and slightly curved.

Measurements

Length, ♂	46 mm.
Length, ♀	41 mm.
Length of abdomen, ♂	38 mm.
Length of abdomen, ♀	32 mm.
Length of hind wings, ♂	29 mm.
Length of hind wings, ♀	30 mm.
Width of hind wings, ♂	10 mm.
Width of hind wings, ♀	10 mm.

The nymphs of this species may be taken in the clearer and swifter streams of Illinois, though not often in very great numbers. The adults do not wander far from the habitat of the nymphs and their period of flight seems to be largely limited to a short time in early summer. The species is supposed to have a northerly distribution, but has been taken near the southern boundary of the state. Several nymphs taken at Urbana early in June emerged June 10, 1915, and subsequent collections of adults show that the insect flies until early fall, although the period of maximum abundance lies between the middle of June and the middle of July.

Specimens have been seen from Havana, Muncie, Oregon, Peoria, Urbana, Cook County, and McHenry County.

Genus HETAERINA Hagen

The nymphs of this genus have shallow mental clefts, and have the margins of the pronotum prominently elevated, and the margins of the lateral gills marked with black or dark spots.

The adults are characterized by cross-veins within the basilar space and by pale stripes on all of the pleural sutures of the thorax.

KEY TO SPECIES

MALES

a. Bases of hind wings tinted with carmine similar to that of the front wings; legs striped, buff and black or dark brown...... *americana.*

aa. Bases of hind wings tinted with brown; legs entirely dark, not striped .... *titia.*

FEMALES

a. Mesepisterna and mesepimera of the thorax without elongate spots of green; uniform bronze.................................. *americana.*

aa. Mesepisterna and mesepimera of the thorax with elongate spots of green .... *titia.*

HETAERINA AMERICANA Fabricius

Nymph.—Color, brown or greenish.

Head pentagonal, about as long as broad; proximal segments of the antennae nearly twice as long as all the remaining ones together; eyes black or dark; labium (Fig. 9) thickset, the cleft of the median lobe hardly extending proximad of the articulations of the labial palpi; labial palpi with three end-hooks and five or six small setae at the

base of the distal segment; caudo-lateral margins of the head forming a blunt tubercle.

Thorax twice as long as broad, a dark lateral line occurring in some individuals, extending from the eyes to the bases of the second pair of wing-cases, though, as a rule, this is much less distinct than in Agrion; lateral margins of the pronotum distinctly elevated, scalloped, and the margins produced at two points on each side to form tubercles (Fig. 23); legs without heavy setae, usually light in color. In younger and more plainly marked specimens the proximal half of the femur is dark brown; this is followed by a light band, beyond which the femur is again brown to the apex; tibiae with three faint, dark rings, the bases and apices also dark; tarsi light in color except the apical half of the third segment and the tarsal claws, which are usually black.

Abdomen: lateral keels feebly developed, not armed with setae though ending abruptly on the apex of segment nine in a short blunt tubercle; ovipositor short and extending hardly caudad of the apex of the ninth abdominal segment; lateral gills three-sided, the median one flat and considerably shorter than the lateral ones; median gill dark along the axis nearly to the apex and with three dark cross-bands; axes of lateral gills sometimes dark, though more frequently the whole gill is light brown or buff and the three margins are each marked with three dark spots (Fig. 79).

Measurements

Length	23 mm.
Length of abdomen	12 mm.
Length of lateral gills	9–10 mm.
Length of metathoracic wing-cases	6 mm.
Length of median lobe	4 mm.
Width of median lobe	1.3–3 mm.

There seems to be a great deal of variation in the color markings of the nymph, especially in the amount of dark pigment, and specimens may be taken which are either practically without body markings of any sort or are so dark and plainly marked as to make the collector think he has taken another species.

Adult; Male.—Color, bronze and metallic green; bases of the wings carmine.

Head metallic bronze; median lobe of the labium subtriangular in outline; labial palpi broad, the terminal segment black and as long as the fixed hook of the first segment; front, vertex, clypeus, and

labrum, thinly pilose; postclypeus metallic green with a small buff spot on the dorso-lateral margin, the anteclypeus with a triangular, median light spot, the remainder dark; labrum buff, but provided with a median, circular, black spot; exposed portions of the mandibles and their trochantins buff; eyes uniform brown.

Thorax: prothorax bronze and black, thinly pilose; caudal lobe of the pronotum convex and projecting caudo-dorsad, the caudal margin entire; proepimeron distinct; pleural sutures all marked with buff-colored stripes, the interpleural suture distinct, cephalad of the metathoracic spiracle; metepimera largely buff but with a median longitudinal stripe of bronze; intersternum with two dark spots on the cephalic border which unite with a dark line covering the suture caudad of it and between the epimera; paraptera subtriangular, black, the caudal margins nearly straight; legs striped, buff and black, the coxae and trochanters buff with a few darker spots, the femora and tibiae mostly dark with lighter stripes on the caudal surfaces, the front femora with nine or ten setae in each row, and the tarsi and claws black; wings clear, the basal fourth, or more, bright carmine, antenodals of the front wing nineteen or twenty, the stigma much longer than the cell caudad of it (Fig. 78).

Abdomen metallic green or reddish brown, dull with age; segments three to seven with pale basal rings, interrupted on the dorsomeson, the lateral surfaces of terga two to seven with a pale longitudinal stripe from base to near apex; first tergum with a pale lateral apical spot; anal appendages (Figs. 34,38) with the superiors twice as long as the inferiors, curved and somewhat expanded at the apex, the lateral margins tuberculate, the mesal margins with two rounded knobs.

Female.—Color, metallic green and in general lighter than that of the male.

Head as in the male except that the antennae have the basal segment entirely pale; postclypeus with a large transverse green spot, and the labrum with a black mesal spot on the dorsal margin.

Thorax with the dorsal carina lined with buff, the pleural sutures with much broader stripes than those of the male; wings (Fig. 74) without carmine at the base, but slightly smoky on the basal third and along the costal margin; stigma white, and the antenodal crossveins about twenty-one in number.

Abdomen metallic green above, the lateral surfaces of the terga with darker apical spots on segments one to nine, and terga two to seven with narrow basal rings of paler color which are interrupted on the dorso-meson; anal appendages of the usual type; ovipositor

(Fig. 112) with broad lateral valves, which are serrate on the ventral margin and extend to the apex of segment ten; prostyles slender, rod-like and bent ventrad at the apex (Fig. 41).

Measurements

Length, ♂	44 mm.
Length, ♀	42 mm.
Length of abdomen, ♂	36 mm.
Length of abdomen, ♀	32 mm.
Length of hind wings, ♂	28 mm.
Length of hind wings, ♀	29 mm.
Width of hind wings, ♂	6 mm.
Width of hind wings, ♀	6 mm.

This species is common along the drainage ditch north of Urbana. Nymphs collected May 27 and 29, 1915, emerged June 19. The species flies until late in October and specimens have been taken as late as October 22. It is apparently limited to the northern half of the state, though probably occurring wherever conditions are favorable.

Specimens have been seen from Galena, Havana, Muncie, Oregon, Peoria, Savanna, Urbana, and McHenry County.

Hetaerina titia (Drury)

Nymph.—Unknown.

Adult; Male.—Color, very dark green and brown.

Head dark brown, faintly metallic; labium with subtriangular median lobe, the palpi with broad black proximal segments, and black distal segments about as long as the fixed hook of the proximal segment; antennae brown; clypeus and labrum shining; front with a broad transverse buff stripe immediately above the clypeus, the front, vertex, clypeus, and labrum pilose, the setae brown.

Thorax black and brown, slightly bronzed; pronotum with the caudal lobe somewhat pointed, convex, and projecting caudo-dorsad; proepimera distinct; interpleural suture distinct cephalad of the spiracle; mesinfraepisternum buff, with a dorsal dark stripe; cephalic shoulder of the mesepimeron light brown, the mesepisternum with a greenish longitudinal stripe extending from the caudal margin nearly to the spiracle; metepimeron with a median black stripe; intersternum with two faint black spots near the cephalic margin; legs uniform dark brown, the tibiae lighter in color than the femora, the setae of the front femora in eleven or fourteen rows, tarsi and claws black;

wings clear, the front wings carmine, and the hind wings brown at base, the color, however, not occupying as much as one-fourth the length of the wing; apices of the wings brown; stigma brown and not longer than the cell caudad of it; front wings with about twenty-four antenodal cross-veins.

Abdomen dark brown; second tergum marked with a paler transverse band beyond the middle, the lateral margins also pale; terga three to six paler along the lateral margins, with narrow basal rings interrupted on the dorso-meson; segments seven to nine inclusive all dull black, the sternum of the tenth buff; anal appendages (Fig. 119) consisting of heavy black superiors, more than twice as long as the inferiors, and having a few tubercles on the lateral surfaces of the apical half, the mesal surfaces with basal knobs and thick subapical projections; inferiors dark brown, reddish at base, short, and with small apical points directed dorsad.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax pale brownish, yellow, and green, the dorsal carina black, the supraepisterna of the mesothorax with a median elongate spot extending cephalad from the wing bases half-way to the cephalic margin, the cephalo-dorsal angles being also green; mesepimera with elongate spots about the middle and nearer the ventral than the dorsal margin; wings without carmine, the bases with only a slight tinge of brown; stigma nearly white, and surmounting one to one and a half cells; antenodal cross-veins of the front wing twenty-one, postnodal cross-veins twenty-six.

Abdomen similar in general color to that of the male, but the lateral margins of terga eight to ten yellowish brown; dorsal carina of the tenth tergum produced into a long blunt spine, beyond the apex of the segment; ovipositor short, brownish yellow, the prostyles slender and the caudal sternites of the eighth segment large and contiguous on the meson as in *americana,* Figure 41.

Measurements

Length, ♂ ....51 mm.
Length, ♀ ....44 mm.
Length of abdomen, ♂ ....41 mm.
Length of abdomen, ♀ ....34 mm.
Length of hind wings, ♂ ....30 mm.
Length of hind wings, ♀ ....29 mm.
Width of hind wings, ♂ ....6–7 mm.
Width of hind wings, ♀ ....6–7 mm.

There are two representatives of this species in the collection of the Illinois State Laboratory of Natural History, both of which were collected at Havana, Illinois. There are also three specimens in the Bolter Collection of the University of Illinois, which are without locality or date labels.

H. tricolor Burmeister is a synonym of *H. titia* (Williamson, '12).

Family *COENAGRIONIDAE*

The nymphs of this family possess flattened gills, the lateral ones being flattened as well as the median. The median lobe of the labium does not have a deep cleft, and the basal segment of the antenna is small and does not exceed the second in length.

The adults are often brightly colored, frequently marked with bright blue or green, but the wings are mostly clear and without smokiness or tints of any kind. The antenodal cross-veins are few, never more than two in number in Illinois species, and the postnodals are also much reduced and fewer in number than in the Agrionidae. The interpleural suture is never distinct as far cephalad as the metathoracic spiracle.*

Key to Subfamilies

NYMPHS

a. Median lobe of labium spoon-like (Fig. 10), the narrowed portion usually much longer than the expanded portion; gills (Figs. 48–52) more or less spatulate, the margins nearly parallel and the tips blunt...... ....Lestinae.

aa. Median lobe of labium not spoon-like (Figs. 11–13), the narrowed portion not much longer than the expanded portion; gills lanceolate, acutely pointed at the tip, the margins not parallel. . Coenagrioninae.

ADULTS

a. M_3 arising much nearer the arculus than the nodus (Fig. 85); front without pale color immediately above the clypeus........Lestinae.

aa. M_3 arising much nearer the nodus than the arculus (Figs. 81–84, 87–90); front with a pale stripe immediately above the clypeus...... ....Coenagrioninae.

*The use of the accessory genitalia in separating the males of closely allied members of this family has failed to prove entirely satisfactory for such species as *Lestes forcipatus* and *disjunctus* and the Enallagma group composed of *E. calverti, carunculatum, civile, divagans,* and *doubledayi.* The structure of the penis in the Enallagma group (Figs. 97,99,101,107,108) is so uniform that the advantage gained by using the character is slight. It may be found that many of these species interbreed —a condition already known to be true of *carunculatum* and *civile*—and it seems almost certain that future investigators will unite *L. forcipatus* and *disjunctus* when more complete biological data are in hand.

Subfamily LESTINAE

The nymphs of this subfamily are long, slender insects with very slender legs. The median lobe of the labium is much contracted at the base, the contracted portion being usually longer than the expanded distal portion. The lateral keels of the abdomen are frequently produced at the apex into a short spinule, and the gills are long, spatulate, and usually without heavy marginal setae and with more or less brown pigment.

In the adults the nature of the wing venation is important. The third median vein and the bridge unite with the R-M trunk nearer the arculus than the nodus, and the stigma always surmounts two or more cells. The long tibial and femoral setae, which are longer than the distance between their bases, as well as the forcipate character of the anal appendages of the male and the presence of a large ovipositor with conspicuous sternites at the base of the cephalic pair of gonapophyses, are also important as diagnostic features.

As a rule the adults are dull in color as compared with the Coenagrioninae and match the color of their usual environment extremely well.

Genus Lestes Leach

The subfamily Lestinae is represented in Illinois by a single genus, Lestes. The nymphs of this genus are recognizable by the character of the labium. The proximal segment of the labial palpus always has two processes mesad of the distal palpal segment, one of them resembling a fork with the median tines broken off, the remaining process consisting of a long non-bifurcate projection with a short heavy hook at the distal end and minute teeth along the mesal margins, (Fig. 10).

The adults are larger than most Coenagrioninae. Vein M_2, of both wings, always arises distad of the second postnodal cross-vein and the stigma rarely surmounts more than three cells. The arculus is one-third or one-fourth the length of the caudal side of the quadrangle. The wings are commonly held horizontally when the insect is at rest.

Keys to Species

NYMPHS

a. Second segment of the labial palpus with three or four setae; labium broad at the proximal end, the contracted portion of the median lobe hardly longer than the expanded portion and about one-third as broad as the latter.......................................*congener*.

aa. Second segment of the labial palpus with only two setae or very rarely three *(uncatus)*; labium narrow at the proximal end, the con-

tracted portion much longer than the expanded portion and less than one-third the width of the latter.

b. Gills pointed at tip (Figs. 51,52); venter of abdomen without a median row of black spots.

c. Ovipositor of female not extending caudad of the eleventh segment; lateral gills not conspicuously contracted beyond the middle . . . . *unguiculatus.*

cc. Ovipositor of female extending caudad of the eleventh segment; lateral gills conspicuously contracted beyond the middle. . *uncatus.*

bb. Gills not sharply pointed (Fig. 49); venter of abdomen with or without a median row of black spots,

c. Lateral keels of segments 1–9 or 2–9 with long apical spines; venter of abdomen without a median row of black spots; gills not conspicuously narrowed beyond the middle. . . . . *vigilax.*

cc. Lateral keels of segments 3–9 or 4–9 with apical spines; gills (Fig. 49) conspicuously narrowed beyond the middle; venter of abdomen with a median row of black spots. . . . . { *forcipatus.* / *rectangularis.* }

ADULTS

Females

a. Dorsum of thorax green.

b. Wings flavescent . . . . *eurinus.*

bb. Wings not flavescent.

c. Occiput and postgenae pale. . . . . *inaequalis.*

cc. Occiput and postgenae black.

d. Basal half of first abdominal segment yellow; stigma always surmounting less than three cells; length usually about 35 mm. . . . . *uncatus.*

dd. Basal half of first abdominal segment black; stigma usually surmounting three or more cells; length 43–47 mm. . . . *vigilas.*

aa. Dorsum of thorax black or dark brown, never green.

b. Metepimera with a black spot above and below the latero-ventral carina . . . . *congener.*

bb. Metepimera without a black spot above and below the latero-ventral carina.

c. Occiput and postgenae pale buff or yellow; abdomen with a greenish tint . . . . *unguiculatus.*

cc. Occiput and postgenae black or very dark brown; abdomen never with a greenish tint.

d. Tarsi black above . . . . { *forcipatus.* / *disjunctus.* }

dd. Tarsi with more or less pale yellow above. . . . . *rectangularis.*

Males

a. Dorsum of the thorax and usually the abdomen metallic green.
  b. Inferiors more than half the length of the superiors, but never longer than the superiors.
    c. Inferiors long and slender; stigma usually surmounting three cells . . . . *vigilax.*
    cc. Inferiors broad and flat; stigma usually surmounting less than three cells . . . . *uncatus.*
  bb. Inferiors either longer than superiors or less than half their length.
    c. Inferiors less than half the length of the superiors; wings flavescent . . . . *eurinus.*
    cc. Inferiors longer than superiors; wings not flavescent. . *inaequalis.*

aa. Dorsum of the thorax and abdomen black or dark brown.
  b. Inferiors shorter than half the length of the superiors; metepimera with black spots near the latero-ventral carina. . . . . *congener.*
  bb. Inferiors more than half the length of the superiors; metepimera without black spots near the latero--ventral carina.
    c. Inferiors sigmoid, the apical two-thirds curved in an opposite direction to the superiors. . . . . *unguiculatus.*
    cc. Inferiors not sigmoid, the apical two-thirds not curved in an opposite direction to the superiors.
      d. Metapleural suture covered with a sooty black stripe. . . . . *disjunctus.*
      dd. Metapleural suture not covered with a sooty black stripe.
        e. Basal tooth of the mesal margin of the superior appendages longer than the tooth of the distal third. . . . . *forcipatus.*
        ee. Basal tooth of the mesal margin of the superior appendages shorter than the tooth of the distal third. . . . . *rectangularis.*

Lestes congener Hagen

Nymph.—Color, pale brown or greenish.

Head twice as broad as long, the caudo-lateral angles not projecting strongly and provided with few setae; antennae long and slender; labium with the median lobe comparatively broad at the base, one-third as broad as the expanded portion and about as long as the latter; mental setae six and sometimes a small seventh on each side, lateral setae four or five, three or four of which are located on the distal segment; inner, mesal lobe of the proximal segment of the palpus as broad as the fork-like process between it and the distal segment of the palpus; labium, when folded, extending caudad between the metacoxae.

Thorax slender; the distances between procoxa and mesocoxa, and between mesocoxa and the metacoxa nearly equal; front femora about half the length of the hind femora and all femora with faint preapical rings of brown; wing-cases short and extending hardly caudad of the second abdominal segment.

Abdomen with poorly developed lateral keels which are provided with apical spines on segments 5–9; gills (Fig. 50) broad, bluntly pointed, and provided with three conspicuous cross-bands of dark pigment, the length of the median gill about four times its greatest width; ovipositor of the female reaching slightly beyond the apex of the tenth segment.

Measurements

Length	16 mm.
Length of abdomen	12 mm.
Length of gills	8 mm.
Width of gills	2 mm.
Length of metathoracic wing-cases	5 mm.
Length of median lobe	3 mm.
Width of median lobe	1.5 mm.

Described from three nymphs received from Dr. E. M. Walker and taken at Prince Edward Island, Canada, Aug. 1, 1915.

Adult; Male.—Color, dull brown and buff or yellow.

Head black, buff below; median lobe of the labium subquadrangular, the median cleft shallow, the labial palpi broad, the distal segments much shorter than the fixed hook, and brownish at the tips; antennae uniform black, the first segment pale at the apex; postclypeus black or dark brown, the anteclypeus, labrum, and genae to the level of the fronto-clypeal suture yellow; lateral ocelli with small yellow spots laterad of them; front, remainder of the vertex, occiput, except occasionally a transverse yellow stripe from the occipital foramen to the compound eyes, black.

Thorax dark brown and yellowish buff, the prothorax dark brown, the median lobes of the pronotum with pale lateral margins, and spots on the meson near the caudal margin; caudal lobe of the pronotum black; proepimeron black; mesostigmal plates with pale lateral angles; dorsal carina usually with a pale line, the mesepisterna, except the ventral half of the infraepisternum, black or dark brown; caudo-dorsal angle of the metepisterna dark brown or black; metepimera with an elongate black spot near the ventro-lateral carina and a similar spot just ventrad of the carina; legs striped, the coxae buff, trochanters black above, the femora black with a narrow pale stripe including the ceph-

alo-ventral row of setae, and a broad dorsal stripe, frequently divided by a faint line or row of spots; tibiae yellow, with a dark stripe including the cephalo-ventral setae; tarsi and claws shining black; wings clear, with eleven postnodals in the front wing and nine or ten in the hind; stigma pale brown, surmounting about one and one-half to two and one-half cells; M_2 arising between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind wing; paraptera brown, caudal margins black.

Abdomen black and buff; terga 1–10 with broad black longitudinal stripes, the lateral margins with broad pale stripes, the pale color extending well to the dorso-meson in the form of basal rings on segments three to seven inclusive; first tergum with a black spot near the latero-ventral margin, terga three to eight with narrow apical black rings reaching their lateral margins; anal appendages black (Figs. 123, 124) and reddish, the superiors compressed, the ventro-mesal margins with large subbasal teeth and a few setae beyond these to the apical third; inferiors shorter than the superiors, usually less than half the length of the latter and provided with a fine brush of silken hairs; sterna 2–9, inclusive, black, the tenth being pale and the first with a black median spot.

Female.—Color similar to that of the male.

Head and thorax similar to those of the male.

Abdomen with interrupted basal rings on terga 3–6, inclusive, the lateral stripes broader than those of the male; sterna 2–7 black, one with a black median spot and eight with a median black stripe; anal appendages of the usual type; superiors black; ovipositor with a black line along the ventral margin, the margins serrate; prostyles dark, long, and nearly straight; ventral margins of the ninth tergum black immediately dorsad of the ovipositor.

Measurements

Length, ♂	34–35 mm.
Length, ♀	32–36 mm.
Length of abdomen, ♂	28 mm.
Length of abdomen, ♀	24–29 mm.
Length of hind wings, ♂	19–20 mm.
Length of hind wings, ♀	19–22 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4 mm.

This species is distinguishable from *disjunctus*, to which it seems most closely related, by the metepimeral spots; the males, by the shortness of the inferior appendages. The compound eyes are blue in life.

It appears on the wing late in summer and may be taken during August and September.

Described from a large series of specimens in the collection of E. B. Williamson. Probably occurs in Illinois.

Lestes disjunctus Selys

Nymph.—Not available for study.

Adult; Male.—Color, blackish brown and yellow.

Head blackish brown above, pale yellow below; median lobe of the labium pale, subquadrangular, the median cleft shallow, but with the usual dark line extending to the base of the piece; antennae black, the two proximal segments very short, much shorter than the two distal ones, the apex of segment two slightly paler; postclypeus almost black, the anteclypeus, labrum, trochantins of the mandibles, and genae, yellowish green; occipital and postgenal regions black, becoming pollinose with age; eyes brownish.

Thorax: prothorax black, largely pollinose in older individuals; proepimera and proepisterna distinct; caudal lobe of the pronotum black, cephalic lobe black, median lobes black, the furrow separating them indistinct; mesostigmal plates black; mesinfraepisterna black or largely black, the supraepisterna blackish brown with the exception of a narrow yellow stripe on the ventro-lateral margins; mesepimera dark brown with the exception of the cephalo-ventral shoulders, which are yellow; metepisterna largely yellow, becoming more or less black with age from the spreading of the black stripe on the metapleural suture; stripes of the metapleural sutures covering about two-thirds of the metepimeron, the remainder of that sclerite yellow; postcoxal areas buff, without black markings; legs slender, pale, the coxae black and pale yellow; femora striped, the hind femora with three black stripes, the middle and front femora with two each; tibiae with a single dark stripe which diffuses over the segment on the distal third; rows of setae of the front femora composed of two and nine setae respectively; wings clear, the antenodal cross-veins two, postnodals about eleven, and M_2 arising between the second and third postnodal cross-veins in both wings; stigma dark brown, surmounting two cells.

Abdomen brown to black, and yellow; first tergum black with the exception of a very narrow apical ring; dorsum of the second tergum dark brown, the lateral margins marked by a narrow longitudinal yellow stripe, the dorsum of 3–6 dark brown, the stripe widened subapically; segment seven black, with a pale lateral stripe; segments eight, nine, and ten black; anal appendages (Fig. 133) blackish brown,

the superiors with tuberculate lateral surfaces, the mesal margins with two nearly equal teeth; inferiors flat, placed horizontally, and slightly swollen at the base and apex.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax without the black stripe on the metapleural suture, and the mesinfraepisternum largely pale.

Abdomen similar to that of the male except that the dorsal brown stripes of the terga are more confined to the dorsal surface and the lateral surfaces are mostly yellow or buff; ovipositor of the female pale except the brown prostyles, extending caudad of the apex of segment ten; anal appendages of the usual type; dorsad of the superiors and between them there is commonly an unpaired blunt process extending conspicuously beyond the apex of the tenth tergum.

Measurements

Length, ♂	32–37 mm.
Length, ♀	35 mm.
Length of abdomen, ♂	25–30 mm.
Length of abdomen, ♀	27 mm.
Length of hind wings, ♂	17–20 mm.
Length of hind wings, ♀	19 mm.
Width of hind wings, ♂	4–4.5 mm.
Width of hind wings, ♀	4.5 mm.

There is great variation in the size of this species as well as in its coloration. The black wash on the metapleural suture is a distinctive character of the older males, but the younger males and the females are not easily separated from *forcipatus* and it is possible that this species is a synonym of the latter. The nymphs are also reported to be nearly identical with *forcipatus*.

Not common in Illinois though occurring in certain localities probably with *forcipatus* and *rectangularis*.

Lestes eurinus Say

Nymph.—Not available for study.

Adult; Male.—Color, metallic green and yellowish buff.

Head metallic green; mouth-parts buff, the median lobes of the labium subquadrangular, with a shallow cleft and a dark line extending proximad to the base; distal segment of the labial palpus dark brown, shorter than the fixed hook; antennae uniform dark brown, the

slender terminal segments long, aristiform; postclypeus black, anteclypeus, exposed portions of the mandibles, and genae brown or greenish yellow, the front, vertex, and all of the occiput and postgenae, metallic green; eyes dark brown.

Thorax metallic green and buff; pronotum metallic green, sometimes pollinose, the caudal and cephalic lobes becoming black with age; proepimeron and proepisternum distinct, black and green; mesostigmal plates black; dorsal carina brown, the mesosupraepisterna metallic green; mesopleural suture brownish, the dorsal half of the mesinfraepisterna, black; mesepimera black or green, the dark color sometimes extending ventrad onto the metepisterna or epimera; remainder of the metapleura and the intersternum yellow, pollinose with age; legs striped, dark brown and buff; coxae buff and dark brown; middle and hind femora with two broad, dorsal, brown or black stripes and a narrow, dorsal, pale one, the apices of the femora dark; front femora without the dorsal, pale, longitudinal line, the entire dorsum being dark brown; tibiae with broad, ventral, brown stripes including the setal rows, the tips dark; tarsi dark brown, the claws deeply notched at the apex, the two teeth nearly equal in length; wings usually flavescent and with fourteen or fifteen postnodal cross-veins in the front wing and twelve to fifteen in the hind; M_2 arising between the third and fourth postnodals in the front wing and between the second and third in the hind; stigma long and narrow, surmounting two and one-half to three and one-half cells in both wings.

Abdomen metallic green and black and buff; dorsum of terga 1–8 inclusive, green, the lateral margins of the same terga buff, the buff stripe becoming dark brown or black on the apices of 4–8; venter of 3–8, and all of segments nine and ten and sometimes seven and eight black, the terminal segments pollinose with age; anal appendages black, the superiors long and curved, the dorso-lateral margins coarsely tuberculate at the apices, the meso-ventral margins with a single sharp basal tooth, and a median projection which has several smaller teeth at the apex; inferiors blunt at the apices and each with a brush of fine setae.

Female.—Color, metallic green, and yellow and black.

Head similar to that of the male.

Thorax: prothorax similar to that of the male; mesothorax with a very broad brownish stripe covering the dorsal carina and a green longitudinal stripe in the middle of each mesosupraepisternum; mesopleural suture with a broad brownish stripe which extends across the dorsal portion of the infraepisternum; metepimera with indefinite, brown, oblique stripes.

Abdomen similar in general color to that of the male; anal appendages largely black or dark brown, the process immediately above and between the superiors projecting as in *disjunctus;* ovipositor with broad lateral valves, the ventral margins coarsely toothed, the distal portion separated from the tenth segment by a considerable interval; more than the ventral half of the lateral valves black; eighth sternites large, conspicuous, nearly black, and contiguous on the meson.

Measurements

Length, ♂	48–49 mm.
Length, ♀	47 mm.
Length of abdomen, ♂	39 mm.
Length of abdomen, ♀	36 mm.
Length of hind wings, ♂	29 mm.
Length of hind wings, ♀	28 mm.
Width of hind wings, ♂	6.5 mm.
Width of hind wings, ♀	5.5 mm.

Described from two males in the Bolter collection of the University of Illinois and a number of females in the collection of E. B. Williamson.

The species is closely related to *vigilax* and *inacqualis,* but both sexes may be distinguished by the flavescent wings; the males, by the short inferior anal appendages.

Probably occurs in Illinois.

Lestes forcipatus Rambur

Nymph.—Color, buff or green.

Head brown and buff; labium, when folded, extending just caudad of the mesocoxae; mental setae six, the lateral setae three, two of which are located on the distal segment of the palpus; antennae of the usual Lestes type.

Thorax about as long as broad, brown; legs slender, the femora all with faint subapical rings and several rows of small setae; tibiae with dark brown apices and with a few three-pointed subapical scales; tarsi with the apical half of the last segment and the tarsal claws dark brown; metathoracic wing-cases extending to the middle of the third abdominal segment.

Abdomen long and slender; lateral keels with heavy setae at the apices on segments five to nine, and a single row of smaller ones from the bases to the apices of the keels of the same segments; terga all with

much more pigment than the sterna, and with small setae distributed evenly over the surfaces; sternum of segment ten with long hair-like setae; gills (Fig. 49) spatulate, broadest just proximad of the middle, three or four times as long as broad; tips rounded or obtusely pointed, black, and two rather indistinct dark cross-bands proximad of the tip; gills sometimes nearly black.

Measurements

Length	19–20 mm.
Length of abdomen	14 mm.
Length of gills	8.5–9 mm.
Width of gills	2–3 mm.
Length of median lobe	2.4 mm.
Width of median lobe	.5–1.7 mm.

Adult; Male.—Color, dark brown and yellow.

Head brown and buff, the median lobe of the labium pale or nearly white, subquadrangular in outline, the median cleft shallow and narrow but apparently extending well towards the base of the piece; proximal segment of the palpus pale, except the distal half of the fixed hook which is black; antennae dark brown with a short basal segment, a much longer second segment, and two terminal aristiform segments which together are much longer than the two basal ones; clypeus and labrum pale yellow or greenish; exposed portions of the mandibles, their trochantins, and the genae as far dorsad as the fronto-clypeal suture, pale; front and vertex brown; occipital and postgenal regions largely dark brown or black, becoming pollinose with age.

Thorax brown and yellow; prothorax brown above, pale below, the proepimera distinct, pale, with a dark dorsal border; caudal lobe of the notum not especially prominent or convex, the cephalic lobe with a median circular black spot and the median lobes each with an irregular H-shaped dark mark; cephalic portion of the prescutum triangular, not deeply depressed; stigmal plates brown and black; pleural sutures and the dorsal carina pale, the pale stripe of the mesopleural suture becoming bluish with age; legs striped, yellow and black, the coxae and trochanters entirely pale, the femora and tibiae striped and the tarsi and claws entirely black; wings with ten to eleven postnodal cross-veins and with M_2 arising between the third and fourth postnodals in the front wing and between the second and third in the hind wing.

Abdomen dark brown, often with a trace of metallic green; sterna of segments three to nine black; dorsum of terga 1–10 with

brown longitudinal bands which are considerably narrowed basally on segments three to seven and conspicuously widened subapically on segments 2–6, the apically widened portion enclosing a lateral yellow spot on segments 3–6; segment nine completely black except a small lateral yellow spot; lateral surfaces of terga 1–8 and ten, yellow; anal appendages (Fig. 137) consisting of broad superiors which are coarsely tuberculate on the lateral surfaces and have two strong, mesal teeth; inferiors nearly as long as the superiors, not laterally compressed, but flattened and placed horizontally.

Female.—Color similar to that of the male.

Head and thorax not appreciably different from those of the male.

Abdomen without the yellow lateral spots of the male; ovipositor extending caudad of the tenth segment, the lateral valves serrate on the apical two-thirds of the ventral margins (Fig. 114).

Measurements

Length, ♂	44 mm.
Length, ♀	41 mm.
Length of abdomen, ♂	30 mm.
Length of abdomen, ♀	32 mm.
Length of hind wings, ♂	23–24 mm.
Length of hind wings, ♀	24 mm.
Width of hind wings, ♂	5 mm.
Width of hind wings, ♀	5 mm.

One of the commonest of the Lestinae in Illinois. The nymphs usually occur along with *rectangularis* in shady stagnant pools. The species is on the wing from early June well into September, and nymphs have been taken at Urbana late in July and at Lexington, Ky., late in August. It seems probable that there is more than one brood of the species per year.

The nymph is inseparable from *rectangularis* and there seems to be no noticeable difference in the length of the developing ovipositor of the female as Walker inferred there might be ('14: 197).

The adult females are also inseparable from *rectangularis* except by the comparatively shorter length and the black tarsal segments. As already mentioned, the females have no important characters which differentiate them from the species *disjunctus*.

Lestes inaequalis Walsh

Nymph.—Unknown.

Adult; Male.—Color, metallic green and black; or bronze and black above, yellow or buff below.

Head green and yellow; labium buff, subquadrangular, the shallow cleft apparently extending to the base of the piece; palpi broad; antennae dull brown, the first segment much shorter than the second and with a pale ring at the distal end; postclypeus metallic green or black, the anteclypeus and labrum, except a small short black stripe on the lateral margins, pale yellowish green; exposed portions of the mandibles, the genae as far dorsad as the fronto-clypeal suture, yellow, the remainder of the front and the vertex, metallic green; occiput and postgenae largely yellow; compound eyes brown.

Thorax metallic green above, yellow or buff below, the pronotum usually black, including the cephalic, median, and caudal lobes, the proepimera black on the dorsal half, the ventral half buff; mesosupraepisterna metallic green, the infraepisterna black on the dorsal half, the remainder yellow; mesepimera metallic green except the cephalo-ventral shoulder, which is yellow; dorso-caudal angles of the metepimera with a triangle of green, remainder of the metapleura and the intersternum pale yellow; legs striped, black and yellow; coxae entirely buff, trochanters, at least the middle and hind ones, with a black dorsal stripe; middle and hind femora with three black stripes, a ventral and two dorsal, and three yellow stripes, the front femora, however, with two black stripes, the cephalic one including the cephalo-ventral row of setae; tibiae with a single ventral black stripe including the cephalo-ventral row of setae; tarsi black, the claws long, black, and deeply bifid at the tip; wings clear, with sixteen postnodal cross-veins in the front wing and thirteen to fourteen in the hind; M_2 arising between the fourth and fifth postnodals in the front wing and between the third and fourth in the hind; stigma surmounting from slightly less than two to two and one-half cells.

Abdomen with the dorsum of terga 1–10 dark, the basal segments metallic green, the apical segments dull black; lateral margins of terga 1–8 pale yellow or buff, the color extending well towards the meson on the base of segments 3–6; sterna one and ten yellow, 3–9 inclusive, black, shining; anal appendages long, black, the superiors pale at the base, the meso-ventral margins with a large basal tooth (Figs. 131, 132) and a number of smaller ones distad of this; dorso-lateral surfaces of the appendages coarsely tuberculate; inferiors longer than the superiors, the tips bent mesad, approximate and finely pilose; parameres of the eighth sternum small, subquadrangular; bases of the inferiors large and apparently fused.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax similar to that of the male excepting that the dorsal carina and mesopleural suture show distinct brown; legs with one dorsal black stripe, frequently reduced to a row of spots; wings with the stigma surmounting slightly less than three cells.

Abdomen with lateral, marginal, pale stripes on all terga, the stripes as a rule broader than those of the male; anal appendages of the usual type, the superiors pale, slightly darker at the tips; ovipositor long, the lateral valves widely separated from the tenth segment at the apex, the ventral half, or more, black; prostyles slender, bent ventrad at the tips, and with a black dorsal stripe; sternites of the eighth segment large, the caudo-dorsal angles acute.

Measurements

Length, ♂	54 mm.
Length, ♀	49 mm.
Length of abdomen, ♂	43 mm.
Length of abdomen, ♀	38.5 mm.
Length of hind wings, ♂	29 mm.
Length of hind wings, ♀	28 mm.
Width of hind wings, ♂	6.5 mm.
Width of hind wings, ♀	5.5 mm.

Described from two males and two females in the collection of Mr. E. B. Williamson.

Not taken in Illinois by the writer, but reported by Walsh ('62) from the vicinity of Rock Island. The species is closely related to *vigilax,* but is distinguishable from the latter by the pale occiput and the long inferior anal appendages of the male.

Lestes rectangularis Say

Nymph.—Color, buff or pale green.

Head elliptical, the width much greater than the length; eyes dark; caudo-lateral margins of the head without setae; labium extending caudad between the metacoxae; mental setae six; lateral setae three, two being on the distal segment of the palpus.

Thorax: mesothorax and metathorax much wider than the prothorax; legs slender, the femora with longitudinal rows of minute setae, the apices of all the femora fuscous and with a subapical dark ring; tibiae with small setae arranged in rows and with fuscous apices; tarsi with the apical half of the third segment and the claws dark brown, the hind tarsi with a very long apical segment and a very short proximal one.

Abdomen: cuticle provided with minute setae and somewhat heavily pigmented with brown; lateral keels with heavy apical setae on segments 5–9 and with about nine smaller setae along the keels to their bases; sterna with a double row of median spots, two to each segment; segment ten hairy beneath; gills similar to those of *forcipatus*, with a row of short setae on both margins, the extreme tips being usually free; the portions of the eleventh segment proximad of the lateral gills bear five or six small setae on the ventral surface; the pigmentation of the gills is usually brownish, though frequently black, but the gill is not as a rule as black as the gill of *forcipatus;* female ovipositor extending to the apex of the tenth abdominal segment.

Measurements

Length	22 mm.
Length of abdomen	17 mm.
Length of gills	9.5 mm.
Width of gills	2.3 mm.
Length of median lobe	4 mm.
Width of median lobe	.5–2.0 mm.

Adult; Male.—Color, dark brown to black, and sulphur-yellow.

Head brown and yellow; labium pale, the median lobe subquadrangular, with a shallow cleft and darker stripe extending proximad to the base; palpi rather short; antennae entirely brown, the first segment much shorter than the second, and the third and fourth much longer than the first two together; postclypeus dark brown, shining, the anteclypeus, labrum, exposed portions of the mandibles, their trochantins, and the genae, shining yellow; front and vertex, dull brown, nearly black, the preocellar furrow very deep and extending laterad nearly to the bases of the antennae; occiput and postgenae black, pollinose with age.

Thorax brown and yellowish; pronotum yellowish buff, the cephalic lobe with a large median brown spot, the median lobes each with an irregular H-shaped mark which covers a large portion of the lobe in the older specimens; caudal lobe blackish brown, the caudo-lateral margins pale; supraepisterna of the mesothorax with a broad, brown, longitudinal stripe from cephalic to caudal margins, covering about three-fourths of the sclerites, the lateral margins of the stripe irregular; mesopleural suture covered by a broad yellow stripe which is widest cephalad, narrowed near the wing bases, and becomes bluish with age; mesepimera with longitudinal median brown stripes extending from near the caudal margin to the cephalic shoulder, widened considerably

caudad and in contact with the mesopleural suture adjacent to the wing bases, narrowed cephalad, and coming to a rather abrupt end on the cephalic shoulder; margins of the stripe irregular; metepisterna pale yellow with a triangular brown spot on the caudo-dorsal angle; remainder of the pleura and the intersternum pale yellow or buff; legs buff and black or dark brown, the coxae and trochanters pale, the femora with two brown stripes each, a cephalo-dorsal one and a ventral one between the rows of setae; tibiae with a single, cephalo-ventral brown stripe including the cephalic row of setae; tarsi and claws brown, the dorsum of the tarsal segments usually more or less yellow; wings with eleven to twelve postnodal cross-veins, M_2 arising between the third and fourth postnodals in the front wing and between the second and third in the hind wing; stigma surmounting slightly more than two cells in both wings.

Abdomen brown and yellowish, long and slender; terga one and two brown on the dorsum, pale on the sides, the stripe on two contracted near the middle; terga 3–7 with yellow lateral margins, narrow interrupted basal rings and longitudinal brown stripes on terga eight and ten, and a triangular, lateral, apical, spot on nine; anal appendages (Fig. 128) brown or blackish, the superiors mostly smooth and not coarsely tuberculate on the lateral surfaces, the basal, mesal tooth small, and much smaller than the tooth at the distal third of each superior; inferiors more than half the length of the superiors, black, the tips laterally compressed.

Female.—Color the same as that of the male.

Head and thorax not appreciably different from those of the male, with the exception of the slightly wider pale stripes on the mesopleural suture.

Abdomen shorter than that of the male; anal appendages of the usual type (Fig. 115); ovipositor extending as far caudad as the apices of the anal appendages or beyond, the lateral valves broad, and with serrated ventral margins, the ventral half being usually black.

Measurements

Length, ♂	50–52 mm.
Length, ♀	46.5 mm.
Length of abdomen, ♂	33–42 mm.
Length of abdomen, ♀	31–34.5 mm.
Length of hind wings, ♂	18.5–24 mm.
Length of hind wings, ♀	20–23 mm.
Width of hind wings, ♂	5 mm.
Width of hind wings, ♀	5 mm.

This species occurs in the same localities in which *forcipatus* is found. Nymphs taken at Urbana emerged as early as May 29 and as late as July 17, the species having a considerable range in the period of emergence. There is a possibility that this species has a two-brooded life cycle.

Specimens have been seen from Urbana, Galena, Lake Villa, Oregon, Savanna, and McHenry County.

Lestes uncatus Kirby

Nymph.—Color, buff or green.

Head broad, the caudo-lateral margins not projecting and without heavy setae; antennae of the usual Lestes type; mental setae six or seven on each side; lateral seta three, two of which are located on the distal segment; marginal setae of the mentum extending to the base of the expanded portion of the median lobe; labium, when folded, extending caudad of the metacoxae.

Thorax: legs very long and slender, the apices of the femora and the apices of the tibiae and the distal half of the third tarsal segments brown; wing-cases extending to the middle of the fourth abdominal segment.

Abdomen with well-developed lateral keels which are provided with short spines on the apices of segments 5–9; cuticle uniform in color, the dorsum of segments nine and ten and the venter of segment ten with long, fine, silken hairs; ovipositor of the female long and extending beyond the apex of the eleventh segment; gills conspicuously contracted beyond the middle as in *rectangularis* and *forcipatus*, rather sharply pointed at the apex, the point similar to that of *unguiculatus*.

Measurements

Length	18 mm.
Length of abdomen	11 mm.
Length of gills	8 mm.
Width of gills	2 mm.
Length of median lobe	5.5 mm.
Width of median lobe	.3–1.6 mm.

Described from a single specimen collected by Dr. Edna Mosher in July, 1915, at Orono, Maine.

Adult; Male.—Color, metallic green and pale yellow.

Head dark green above, pale below; occiput black, the median lobe of the labium pale and subquadrangular with a typical cleft;

palpiger short and indistinct; fixed hook of the proximal segment longer than the distal segment, black at the tip; antennae black, the second segment pale at the distal end; postclypeus black; the anteclypeus, labrum, exposed portions of the mandibles, their trochantins and the genae, pale yellow; front, vertex, clypeus, and labrum thinly pilose, the setae pale; eyes pale yellow.

Thorax metallic green, black, and yellow; pronotum green, the caudal lobe narrow, the median lobes not distinctly separated, proepimeron and proepisternum black, pollinose with age, the suture between the epimeron and notum indistinct; dorsal carina of the mesothorax black; mesosupraepisternum green, the mesinfraepisternum and the mesopleural suture black; mesepisternum green with the exception of the cephalo-ventral shoulders; metapleural suture usually black, the stripe indefinite, increasing in extent with age and covering a large portion of the metepimera; postcoxal areas buff; legs black and buff, the coxae pale and black, femora with three black stripes alternating with three buff-colored ones; tibiae, tarsi and claws black; setal rows of the front femora composed of two and nine setae respectively; wings clear, the antenodal cross-veins two in number, postnodal cross-veins ten to eleven; stigma of the front wing surmounting two cells; stigma of the hind wing slightly smaller than that of the front wing; M_2 originating between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind wing.

Abdomen metallic green; first tergum green on the dorsum and with a small, black, lateral basal spot on each side; dorsum of the second tergum green, the green extending well onto the sides, the latero-ventral margins, however, being pale; terga 3–7 with broad, longitudinal green stripes, widened subapically, and with narrow basal, dorsally interrupted, yellow rings and longitudinal lateral stripes; all of segments eight, nine, and ten green above, black or pollinose below; sternum of segment one with a median black spot at the caudal end, 3–10 black; superior anal appendages (Figs. 135, 136) black at the tip, brownish at the base, the lateral surfaces tuberculate, the mesal margins with a large basal tooth and a row of small ones beyond to the distal third; inferiors broad, black and distinctly expanded at the apex.

Female.—Color, metallic green and yellow.

Head similar to that of the male.

Thorax with pale dorsal carina and mesopleural sutures, and usually lacking the black stripe on the metapleural suture.

Abdomen: proximal half of the first tergum with a pale dorsum; terga 8–10 with broad lateral stripes of yellow; first sternum without the black spot and the eighth, instead of being all black, has a mesal

stripe; superior anal appendages black at the tips, slightly longer than the inferiors; ovipositor with the lateral valves black on the ventral half, the apex extending well caudad of the tenth segment; prostyles black at the tip and on the dorsal surfaces, the tips extending beyond the apices of the anal appendages.

Measurements

Length, ♂	34 mm.
Length, ♀	39 mm.
Length of abdomen, ♂	26–28 mm.
Length of abdomen, ♀	29 mm.
Length of hind wings, ♂	21 mm.
Length of hind wings, ♀	23 mm.
Width of hind wings, ♂	4.5 mm.
Width of hind wings, ♀	4.5 mm.

A moderately common species though not as common as either *rectangularis* or *forcipatus*. Taken at Oregon July 1, 1915, at Freeport July 8, and at Urbana.

Lestes unguiculatus Hagen

Nymph.—Color, light brown or green.

Head about twice as broad as long, subelliptical, the caudo-lateral angles not projecting, and provided with a few weak setae; antennae slender, entirely pale, the third segment longest, segment two longer than one; labium slender, and extending caudad of the mesocoxae; mental setae seven, lateral setae three, two of which are located on the distal segment of the palpus; lateral marginal setae of the mentum about twelve, the row extending from the articulation of the palpus to the base of the expanded portion.

Thorax slender, much contracted behind the head, about as broad as long; legs slender, the femora with rows of short setae and faint preapical rings of brown; tibiae with rows of setae, the apices brown; tarsi pale except the apical half of the third segment which is brown; metathoracic wing-cases extending caudad to the middle of the third abdominal segment.

Abdomen long and slender, the lateral keels moderately well developed and possessing spines at the apices of segments 5–9; venter of the abdomen usually much paler than the dorsum though sometimes with faint median stripe and stripes just ventrad of the lateral keels; caudo-lateral angles of terga 1–8 sometimes with darker spots; gills

widest near the base, and gradually tapering to a point at the apex, not conspicuously contracted beyond the middle (Figs. 51, 52).

Measurements

Length	19 mm.
Length of abdomen	14 mm.
Length of gills	9 mm.
Width of gills	1.5 mm.
Length of median lobe	2 mm.
Width of median lobe	.5–1.5 mm.

Adult; Male.—Color, dull brown or metallic green and yellow.

Head metallic green and brown, often more or less bronze; median lobe of the labium subquadrangular, with the usual cleft; proximal segment of the antennae with pale spot at the distal end, the remaining segments dark; postclypeus dull metallic brown, the anteclypeus, labrum, and the exposed portions of the mandibles, their trochantins, and the genae, shining yellow; eyes slate-gray; occipital and postgenal regions wholly yellow.

Thorax dull brown and yellow; caudal margin of the pronotum entire, the caudal lobe narrow and not convex; cephalic lobe much longer and possessing a median, circular, black spot; median lobes with irregular H-shaped black or dark marks, one to each lobe; proepimeron distinct, pale brown, black on the dorsal margin; mesosupraepisterna dull metallic brown, sometimes greenish, with the lateral fourth yellow; mesopleural suture with a broad yellow stripe; mesepimeron almost entirely brown, with the exception of the cephalic shoulder; mesinfraepisternum with the dorsal half brown or greenish in older specimens and with a median spot in younger individuals, the remainder of the sclerite pale; metepisterna with triangular brown spots adjacent to the wing bases; metapleural suture and the metepimera pale buff; postcoxal areas pale yellow, without dark spots; paraptera crescentic, the caudal margins faintly emarginate; legs striped, the coxae and the trochanters buff, the femora pale yellow with two black or dark brown stripes; tibiae with a single brown stripe including one of the two rows of setae; tarsi and claws black; front femoral rows of setae containing three and eight setae respectively; wings clear, the postnodal cross-veins about eleven, and M_2 originating between the second and third in the front wing and between the first and second, usually near the second, in the hind wing.

Abdomen mostly yellow in recently emerged specimens, dark metallic green or brown in older ones; dorsum of the first tergum brown

on the caudal half; terga 2–10 all with brown, dorsal, longitudinal bands, extending from the cephalic nearly to the caudal margins, the bands being slightly enlarged at the caudal ends; terga 2–10 with narrow rings of brown on the caudal margins; sterna 3–8 black; nine and ten, pale; anal appendages (Figs. 125, 126) consisting of strong superiors, coarsely tuberculate on the lateral surfaces and hairy at the apices, the mesal margins possessing a large basal tooth and a number of smaller ones beyond this to about the distal third; inferior appendages sigmoid, the distal two-thirds curved in an opposite direction to the superiors.

Female.—Color similar to that of the male.

Head and thorax identical with those of the male.

Abdomen similar to that of the male with the exception of the dorsa of the cephalic terga, which are as a rule paler in color, and terga nine and ten, which possess a mesal dark line; ovipositor reaching apex of tenth segment, the lateral valves black below, the ventral margins serrate or coarsely toothed.

Measurements

Length, ♂	39 mm.
Length, ♀	35 mm.
Length of abdomen, ♂	27 mm.
Length of abdomen, ♀	27 mm.
Length of hind wings, ♂	21 mm.
Length of hind wings, ♀	22 mm.
Width of hind wings, ♂	5 mm.
Width of hind wings, ♀	5 mm.

A very common species at Urbana, occurring in abundance in pools north of town. The nymph is easily separated from *rectangularis* and *forcipatus* by means of the shape of the gills. The adult is also easily separated from *rectangularis* and *forcipatus* and seems to be most closely related to *uncatus*, from which species it differs mainly in color though also in the shape of the anal appendages of the male and the length of the ovipositor of the female. The nymph is more closely related to *uncatus* than to any other species.

The species has a wide distribution in Illinois and flies from early June to August.

Lestes vigilax Hagen

Nymph.—Color, light brown or green.

Head broad, about twice as broad as long, the caudo-lateral angle not projecting and without setae; antennae slender and of the usual

Lestes type; labium very slender and when folded extending caudad about to the metacoxae; mental setae five or six; lateral setae three, two of which are located on the distal segment of the palpus; marginal mental spinules apparently wanting or few in number and not extending proximad to the base of the expanded portion; the teeth of the mesal margins of the mesal lobe of the proximal segment of the palpi are large and square and the furrow representing the median cleft of the median lobe is conspicuous and extends proximad one-third the length of the expanded portion.

Thorax slender; legs very slender, the femora and tibiae with rows of short setae; femora with subapical rings of brown, the tips of the tibiae and the distal half of the third tarsal segment also dark brown; wing-cases extending about to the middle of the third abdominal segment; lateral keels with strong apical spines on segments 1–9 inclusive, the seta at the apex of nine especially long; gills (Fig. 48) very long and slender and of about equal width throughout, the apices bluntly pointed; ovipositor of the female nearly reaching the apex of segment ten.

Measurements

Length	21–30 mm.
Length of abdomen	17–22 mm.
Length of gills	13 mm.
Width of gills	1.25–1.75 mm.
Length of median lobe	3.3–4 mm.
Width of median lobe	1.5–2 mm.

The nymph is the longest of any species of Lestes. It is easily recognizable by the slender gills (Fig. 48) and the apical setae of the lateral keels.

Described from a single exuvium obtained from Dr. E. M. Walker and several specimens in the collection of the Illinois State Laboratory of Natural History from Grass Lake and Havana, Ill.; dates of collection of the specimens from Grass Lake June 23, 24, 1892.

Adult; Male.—Color, dull metallic green and buff.

Head dull greenish black or black; median lobe of the labium subquadrangular, the median cleft shallow; fixed hook of the palpus black at the apex; antennae black, the tip of the first segment slightly pale, the second segment twice as long as the first; postclypeus black, the anteclypeus brown; labrum pale green; exposed portions of the mandibles, their trochantins, and the genae, pale brown; front and vertex metallic green.

Thorax metallic green, prothorax largely black, becoming pollinose with age; suture between pronotum and the proepimeron indistinct; caudal lobe of the notum much narrower than the cephalic lobe and considerably widened on the meson; furrow separating the median lobes obscure; cephalic portion of the prescutum small, triangular, and little depressed; mesosupraepisterna and mesepimera green, the mesopleural suture and the dorsal carina with pale lines which become dark with age; mesinfraepisternum black, the metapimera, metepisterna and intersternum pale at first but black or pollinose with age; legs buff and black; coxae pale and black, femora almost entirely black, with a narrow pale stripe between the setal rows on the ventral surface, and a short stripe on the dorsal surface of the hind femora; rows of front femoral setae consisting of two and eight setae respectively; tibiae and tarsi black; wings clear, the antenodal cross-veins two, postnodals fifteen to seventeen in the front wings and twelve to thirteen in the hind wings; M_2 arising between the fourth and fifth postnodal cross-veins in the front wings and between the third and fourth in the hind wings; stigma usually surmounting three cells, light brown or nearly white in color.

Abdomen metallic green and black; terga 1–6 with narrow lateral stripes, 7–10 black; sterna of all segments black, the first sometimes light, but black in older specimens; superior anal appendages black, the lateral surfaces tuberculate and the mesal margins with a basal hook and two indentations between this and the apical third; inferiors long and slender, not dilated at the apex (Figs. 129, 130).

Female.—Color, metallic green and black.

Head and thorax similar to those of the male.

Abdomen long and very slender, the dorsum of terga 1–10 and apical rings on all terga except the two caudal ones dull brown or greenish; sterna 2–8 mostly black, ovipositor long and slender, the prostyles long and the eighth sternites at the base of the cephalic pair of gonapophyses with a long dorso-caudal projection.

Measurements

Length, ♂	43–47 mm.
Length, ♀	43–45 mm.
Length of abdomen, ♂	34–38 mm.
Length of abdomen, ♀	34–36 mm.
Length of hind wings, ♂	21–25 mm.
Length of hind wings, ♀	26–27 mm.
Width of hind wings, ♂	5 mm.
Width of hind wings, ♀	6 mm.

Males possessed by the Illinois State Laboratory of Natural History were collected at Cedar Lake, Ill.,—Lake Villa—August 3, 1887. The female was described from material obtained from Mr. E. B. Williamson.

The species has not been seen as far south as Urbana.

Subfamily COENAGRIONINAE

The nymphs have short labia, gradually contracted proximad and not at all spoon-like. The gills are more or less lanceolate, acutely pointed at the tip, and the smaller tracheae are commonly well developed, pigmented, and visible to the naked eye. The abdomen is short in proportion to its diameter.

The adults are distinguished from the Lestinae by means of the wing venation, M_3 arising nearer the nodus than the arculus. The femoral and tibial setae are much shorter than those of the Lestinae and the coloration of the body is frequently bright, the yellows, blues, and reds being often conspicuous. The anal appendages of the male are short and the eighth sternites at the base of the cephalic pair of gonapophyses of the female are reduced to small triangles or are wanting.

Key to Genera

NYMPHS

a. Gills half as broad as long (Figs. 58, 63, 67, 68); labium without mental setae; proximal segment of the labial palpus with two similar fixed hooks .... *Argia.*

aa. Gills not more than one-third as broad as long; labium provided with mental setae; proximal segment of the palpus with a single, sharp, fixed hook, and a truncate process with teeth at the apex.

b. Caudo-lateral angles of the head projecting and forming a blunt tubercle, the margins of the head much contracted between the tubercles and the eyes.

c. Gills (Fig. 59) without cuticular pigment, one-third as broad as long, the margins thickly provided with setae which extend from the base to the apex of the gills............. *Amphiagrion.*

cc. Gills with cuticular pigment, not more than one-sixth as broad as long, the margins sparsely setose.............. *Chromagrion.*

bb. Caudo-lateral angles of the head not projecting and forming a blunt tubercle, the margins of the head not contracted between the tubercles and the eyes.

c. Gills with the tracheal branches much more numerous at the widest portion of the gill...................... *Nehalennia.*

cc. Gills with the tracheal branches equally distributed throughout the length of the gill.

d. Gills with long, tapering points, the cuticular pigment, if present, always in cross-bands; mental setae of the labium usually four.

e. Gills without cuticular pigment (Fig. 60); lateral keels without setae; nymphs of small size, full-grown individuals rarely more than 14 mm. in length including gills.......... .... *Anomalagrion.*

ee. Gills usually with cuticular pigment in the form of arcuate cross-bands; lateral keels with several rows of small setae; nymphs larger, when full-grown 18–20 mm. in length including gills .... *Ischnura.*

dd. Gills with blunt points (Figs. 56, 57, 70–72, 75–77a, 80), or if with long points, then with cuticular pigment other than in cross-bands; mental setae usually three (four in *E. calverti* and *E. cyathigerum)* .... *Enallagma.*

ADULTS

a. Cephalic row of setae of all tibiae twice as long as the spaces between their bases; postnodal cross-veins of the front wings twelve or more in number; M_2 arising between postnodal cross-veins five and nine in the front wing .... *Argia.*

aa. Cephalic row of setae of all tibiae less than twice as long as the spaces between their bases; postnodal cross-veins of the front wings usually less than twelve in number; M_2 arising between the third and fifth, rarely sixth, postnodal cross-veins in the front wing.

b. Dorsum of the thorax metallic green or bronze; female pronotum with the caudal lobe trilobed......................... *Nehalennia.*

bb. Dorsum of the thorax not metallic green or bronze; female pronotum not with the caudal lobe trilobed.

c. Postocular spots wanting; mesopleural suture without a distinct black stripe, the stripe not wider than the suture itself.

d. Dorsum of abdominal terga 1–6 reddish or buff; width of the stigma measured between costa and Sc_2+R_1 much greater than its length; female with a heavy spine on the caudal margin of the eighth sternum.......................... *Amphiagrion.*

dd. Dorsum of abdominal terga 1–6, black; width of the stigma measured between costa and Sc_2+R_1 not greater than its length; female without a heavy spine on the caudal margin of the eighth sternum .... *Chromagrion.*

cc. Postocular spots present; mesopleural suture usually with a distinct black stripe, the stripe wider than the suture itself.

d. M_2 arising between the fourth and sixth postnodal cross-veins in the front wing and between the third and fourth in the hind . . . . *Enallagma.*

dd. M_2 arising between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind.

e. Dorsum of the fourth abdominal tergum black, except a narrow basal ring; stigma of the front wing of the male not remote from the margin . . . . *Ischnura.*

ee. Dorsum of the fourth abdominal tergum orange or yellow with the exception of a basal and apical spot in the male and a small apical spot in the female; stigma of the front wing of the male remote from the margin (Fig. 83) . . . . *Anomalagrion.*

Genus Argia Rambur

The nymphs are characterized by the short thickset form, the abdomen being as a rule much shorter than that of closely allied genera. The labium is broad at the proximal end of the median lobe and the median process of the proximal palpal segment consists of a simple hook similar to the mesal hook of the same segment. The gills are broad and oval to elliptical in outline, are heavily pigmented, and the legs are long and slender, with a number of dark brown rings on the femora and tibiae. The body is dark in color for the most part, and the species live either in the mud on the bottom of sluggish streams or under rocks or debris in the swifter currents.

The adults are distinguishable from other genera by the dorsal carinae of the femora and the long setae of the front tibiae; by the point of origin of vein M_2, which is always beyond the fifth postnodal cross-vein, and by the number of postnodal cross-veins of the front wing, the latter ranging from twelve to seventeen in number. The parameres of the ninth sternum of the male extend caudad to the apex of the segment, and the sternites at the base of the cephalic pair of gonapophyses are distinct and subtriangular.

Key to Species

NYMPHS

a. Labial palpi with a single weak seta on the proximal segment; gills broad at the tip (Fig. 58), the margins parallel for a considerable distance, and without light cross-bands and not coarsely spotted with dark pigment . . . . *moesta putrida.*

aa. Labial palpi with two or more setae on the proximal segment; gills tapering to a point, the margins not parallel or parallel for only a

short distance (Figs. 63, 67, 68), and frequently with one or more light cross-bands and coarsely spotted with dark pigment.

b. Gills broadest beyond the middle, decidedly ovate (Fig. 63) and frequently with a V-shaped cross-band near the apex; median lobe projecting between and distad of the articulations of the labial palpi much less than one-third the length of the proximal segment of the palpi (Fig. 11) . . . . *violacea.*

bb. Gills broadest at middle, elliptical (Figs. 67, 68) and never with a V-shaped mark near the apices; median lobe of the labium projecting between and distad of the articulations of the labial palpi one-third or more of the length of the latter . . . . { *apicalis.* *tibialis.* }

ADULTS

Females

a. Wings smoky . . . . *fumipennis.*

aa. Wings not smoky.

b. Stigma surmounting more than one cell in the hind wing; mesepimera without a broad dark stripe on each, ventrad of the mesopleural suture; mesostigmal plates (Fig. 154) with a sharp median projection on the caudal margin . . . . *moesta putrida.*

bb. Stigma surmounting a single cell or less in the hind wing; mesepimera with or without *(apicalis)* a broad dark stripe on each, ventrad of the mesopleural suture; mesostigmal plates without a sharp median projection on the caudal margins.

c. Front, vertex, and occiput wholly brown; caudal margins of the mesostigmal plates forming a thin blade which projects dorsad . . . . *sedula.*

cc. Front, vertex, and occiput with more or less black pigment; caudal margins of the mesostigmal plates not forming a thin blade which projects dorsad.

d. Black stripe of the mesopleural suture extending more than half-way to the wing bases from the infraepisternum.

e. Caudal margins of the mesostigmal plates (Fig. 140) not projecting caudad at the caudo-mesal angles; terga 1–5 of the abdomen with the mesal pale line narrower than the black lines on either side . . . . *tibialis.*

ee. Caudal margins of the mesostigmal plates projecting caudad at the caudo-mesal angles and forming a rounded lobe (Fig. 142); terga 1–5 with the pale mesal stripe much broader than the black stripe on either side . . . . *violacea.*

dd. Black stripe of the mesopleural suture extending less than halfway to the wing bases from the infraepisternum . . . . . . *apicalis.*

Males

a. Wings smoky . . . . *fumipennis.*

aa. Wings not smoky.

b. Stigma surmounting more than one cell in both wings; abdominal terga 8–10 black with dorsal spots of brown, or entirely black . . . . *moesta putrida.*

bb. Stigma surmounting one cell or less; terga 8–10 inclusive or nine and ten, blue, never black except the eighth, and never with brown markings.

c. Terga nine and ten blue . . . . *sedula.*

cc. Terga eight, nine, and ten blue.

d. Black stripe of the mesopleural suture extending from the mesinfraepisternum to the wing bases.

e. Terga 1–5 with the pale color of the dorsum limited to a very narrow mesal line and narrow basal rings . . . . . . *tibialis.*

ee. Terga 1–5 with the pale color of the dorsum occupying the greater portion of the segments, the black confined to small, apical, lateral spots on 1–4 and an apical ring in addition on the fifth . . . . *violacea.*

dd. Black stripe of the mesopleural suture extending much less than half-way from the mesinfraepisternum to the wing bases . . . . *apicalis.*

Argia apicalis (Say)

Nymph.—Color, dark brown.

Head one-third wider than long, pentagonal, the caudo-lateral angles strongly projecting and armed with heavy setae; eyes black; antennae dark brown except the first and the last two or three segments; labium very broad, the median lobe dark in color, without mental setae but with about twelve marginal setae; labial palpi with three or four setae on the proximal segment and with a long movable distal segment much longer than the fixed hooks; labium, when folded, extending caudad of the procoxae, but not reaching the mesocoxae.

Thorax dark in color; legs conspicuously banded, the dark portions consisting of the second segment of the trochanters, two broad bands on each femur and three on each tibia, the proximal one on the tibiae being narrow, the next one slightly broader and located about the middle, and the third nearly equal in width to the median band and covering the apex; tarsi of the usual form, dark brown in color; wing-cases extending caudad to the middle of the fifth abdominal segment.

Abdomen half as broad as long, dark brown in color, the dorsum with a pale median stripe which widens noticeably on segments eight, nine, and ten; gills (Fig. 67) elliptical, smoky, frequently possessing one or two pale transverse bands and usually with a number of coarse spots of pigment; apices of the gills bluntly pointed, the margins hairy, but without heavy setae; ovipositor of the female extending to the apex of segment ten.

Measurements

Length	14 mm.
Length of abdomen	8 mm.
Length of gills	6 mm.
Width of gills	3 mm.
Length of metathoracic wing-cases	4.5 mm.
Length of median lobe	3 mm.
Width of median lobe	1–2 mm

Adult; Male.—Color, light blue (light amparo blue), or buff (warm buff) and black.

Head: exposed portions of the mouth-parts buff or light blue, the median lobe of the labium subtriangular, the cleft shallow and obtuse at the proximal end; proximal segment of the labial palpus about three times as long as the distal segment; fixed hook only slightly longer than the distal segment, black; distal segment black; antennae black with the exception of the first segment which has a pale lateral stripe; clypeus and labrum, genal region, exposed portions of the mandibles, and the front dorsad to the level of the lateral ocelli, blue; vertex black; ocellar area black, the latter sending a black line ventrad to each antenna; postocular spots present, circular, blue or brown; occiput and postgenae yellow with the exception of small black spots on the postgenae, near the ventral margins of the compound eyes.

Thorax light blue or buff, black, and sulphur yellow; prothorax black and blue; caudal lobe of the pronotum black, median lobes with circular blue spots; noto-epimeral suture indistinct; proepimera blue or buff, the dorsal margins black; mesopleura and metapleura blue or olive-buff, and without black markings except a short stripe covering the dorsal half of the mesinfraepisternum, which extends caudad on the mesepimeron for about one-fifth of the length of that sclerite; postcoxal areas buff or yellow; legs striped with black and yellow, a stripe on each side of the femoral carinae and one on each tibia enclosing the cephalo-ventral row of setae; tarsi black, the second and

third segments frequently yellow above; wings with twelve to fourteen postnodal cross-veins, the stigma surmounting a single cell or less, and M_2 arising between the seventh and eighth, or eighth and ninth, postnodal cross-veins in the front wing and between the sixth and seventh in the hind wing.

Abdomen blue or buff and black, the black placed as follows—a spot on the first tergum, longitudinal dorsal stripes on 1–7 which extend well onto the lateral surfaces of terga 3–7 at their apices, and the lateral margins of terga 8–10 inclusive; the yellow or blue forms lateral stripes of pale color on terga 1–7, narrow basal rings on 3–7 inclusive, and narrow apical ring on one; dorsum of terga 8–10 blue; anal appendages (Figs. 151, 152) consisting of short black superiors and longer bifurcate inferiors, the dorsal emargination of the tenth tergum about one-third the length of the segment; sterna 2–10 black, one, pale buff.

Female.—Color similar to that of the male.

Head: cephalic aspect entirely blue or buff with the exception of black spots ventrad and dorsad of the lateral ocelli and black rings around the postocular spots.

Thorax as in the male, though usually somewhat lighter in color; mesostigmal plates as shown in Figure 153 with a very small caudal projection near the caudo-mesal angles; caudal lobe of the pronotum with more or less blue or buff and the mesopleural dark stripes of the infraepisternum and epimeron paler than those of the male.

Abdomen with the dorsum of the eighth and ninth terga black with a dorsal yellow stripe and with dark brown or yellow on the lateral surfaces; tenth tergum dark brown above, paler on the sides, the dorsal, median emargination extending nearly to the base of the segment; anal appendages of the usual form and pale in color; ovipositor with light brown lateral valves, the prostyles darker.

Measurements

Length, ♂	38 mm.
Length, ♀	36 mm.
Length of abdomen, ♂	30 mm.
Length of abdomen, ♀	28 mm.
Length of hind wings, ♂	24 mm.
Length of hind wings, ♀	23 mm.
Width of hind wings, ♂	5.5 mm.
Width of hind wings, ♀	5.5 mm.

A common species along all large-sized streams in Illinois. The nymphs live in the mud at the bottom, but when mature approach the

banks and hide among dead submerged weeds or rubbish. The eggs are deposited below the water on driftwood, and large numbers of females may sometimes be seen congregated about an old log at the water's edge depositing eggs.

Argia fumipennis (Burmeister)

Nymph.—Unknown.

Adult; Male.—Color, dull brown and black.

Head: dark brown and black; median lobe of the labium buff, subtriangular; antennae brown, the first segment nearly globular, the second segment about twice as long as the first; clypeus, labrum, exposed portions of the mandibles and their trochantins, genae, and the front dorsad of the clypeus to the median ocellus, dark brown or buff; vertex with a transverse black stripe which includes the ocellar area; there is, however, a large brown spot ventrad of each lateral ocellus and a narrow median stripe between them; postocular spots large, contiguous with the margins of the compound eyes and connected by means of a broad stripe caudad of the ocelli; occiput and postgenae buff; compound eyes brown.

Thorax dark brown, black, and buff; pronotum dark, the cephalic lobe buff, the median lobes with large, pale, lateral spots; caudal lobe dark, with a paler spot on each lateral angle; proepimeron and proepisternum of the propleura not distinct, brown in color, the dorsal border darker; dorsal carina of the mesothorax covered by a broad black stripe which also covers about half of each mesosupraepisternum; mesepimera with a broad dark stripe ventrad of the mesopleural suture, the stripe extending cephalad across the infraepisterna and forking about half-way from the infraepisternum to the wing bases; margins of the paraptera dark brown, the remainder buff; metapleural suture with a dark line; remainder of the meso- and metapleura and the postcoxal areas buff; femora each with a broad dark brown or blackish line, the remainder buff; tibiae pale buff above, darker below, the dark brown color including the cephalo-ventral row of setae; wings distinctly tinged with brown; postnodal cross-veins sixteen in the front wing and fifteen in the hind; M_2 arising between the seventh and eighth postnodal cross-veins in the front wing and between the sixth and seventh in the hind wing; stigma surmounting a single cell or less.

Abdomen dark brown; dorsum of terga 1–7 dark brown, the lateral margins paler in color; narrow basal rings on the cephalic margins of terga 3–6; terga 8–10 bluish green; sternum one buff, 3–10 brown; anal appendages (Figs. 143, 144) with the superiors shortest, inferiors longer, thickset.

Female.—Color similar to that of the male.

Head and thorax similar to those of the male except that the color is paler.

Abdomen: terga 8–9, inclusive, brown with a median buff stripe and a lateral stripe on each side; tergum ten, buff; ovipositor buff, the prostyles short and extending caudad of the anal appendages.

Measurements

Length, ♂	33 mm.
Length, ♀	34 mm.
Length of abdomen, ♂	27 mm.
Length of abdomen, ♀	28 mm.
Length of hind wings, ♂	20 mm.
Length of hind wings, ♀	23 mm.
Width of hind wings, ♂	5.0 mm.
Width of hind wings, ♀	5.5 mm.

This species has not been reported from Illinois but has been reported from Kentucky, and may possibly be taken in southern Illinois.

Described from specimens in the Bolter Collection of the University of Illinois and others in the collection of Mr. E. B. Williamson,—all from Florida.

Argia moesta putrida (Hagen)

Nymph.—Color, dark brown.

Head broad and flat, pentagonal, the caudo-lateral angles projecting caudad and possessing a few short setae; antennal segments dark except the first, which is pale; labium very broad, the median lobe but slightly narrowed at the base and projecting strongly between the labial palpi; mental setae wanting, the lateral marginal setae about twelve; labial palpi with two fixed hooks, both shorter than the sharp distal segment, the one adjacent to that segment shortest; setae of the labial palpi reduced to a single weak hair-like one.

Thorax brown; the pronotum projecting strongly laterad; legs not conspicuously banded as in *apicalis*, but possessing a faint preapical ring and with the proximal two-thirds evenly infuscated; tibiae with dark apices; tarsi mostly pale; femora with indefinite rows of short heavy setae; wing-cases extending to the middle of the fourth abdominal segment or beyond.

Abdomen uniform brown, the lateral keels feebly developed and without setae; styli of the male very long, nearly reaching the apex of

the tenth abdominal segment and setose on the ventral margin; apical margin of the tenth abdominal tergum cleft nearly to the base, the margin thickly beset with short spines; gills (Fig. 58) uniform dark gray or nearly black, paler at the tip, long, broad, and bluntly pointed, the margins parallel for a considerable distance.

Measurements (young nymphs)

Length	14 mm.
Length of abdomen	9 mm.
Length of gills	5–6 mm.
Width of gills	3 mm.
Length of metathoracic wing-cases	4 mm.
Length of median lobe	3.5 mm.
Width of median lobe	1.5–3 mm.

Described from a male specimen in the collection of the Illinois State Laboratory of Natural History taken from the Kankakee River six miles below Kankakee, June 1, 1901, and several specimens obtained from Dr. E. M. Walker.

Adult; Male.—Color, black and cinnamon-buff.

Head: median lobe of the labium buff, subtriangular; distal segment of the palpus dark at the tip; antennae black, first two segments nearly equal, the first pale at the apex, the third segment longest; clypeus and labrum buff, the postclypeus with two indefinite black spots near the fronto-clypeal suture; labrum with a mesal spot on the dorsal margin; front and genae buff, the pale color extending dorsad to the ocelli, the black confined to an indefinite ring around the median ocellus and wedge-shaped marks on the vertex; occiput black; the surface of the head dorsad of the postclypeus and the occiput often becomes pollinose and obscures the original coloration.

Thorax: prothorax dark brown or black, more or less pollinose with age; caudal lobe of the pronotum black, median lobes each with a large, pale, circular, median spot which often becomes pollinose before the rest of the notum; proepimeron pale, the noto-epimeral suture indistinct though marked by a black stripe; dorsal carina black and a black stripe on each side one-half the width of the mesepisterna; mesopleural suture lined with black; mesepimera with a broad sooty line extending the entire length of the sclerite and more than half as wide; metapleural suture lined with black, the metepisterna and metepimera and the postcoxal areas usually buff; legs rather short, striped, the dorsum of all femora with a broad stripe including the cephaloventral row of setae; tarsi and claws black; wings clear, the stigma

surmounting one and one-half to two cells, the postnodal cross-veins of the front wing sixteen or seventeen, of the hind wing fourteen or fifteen; M_2 arising between the sixth and seventh or seventh and eighth postnodals in the front wing and between the fifth and sixth in the hind wing.

Abdomen black, with pale basal rings on segments 3–7 inclusive, faint dorsal and lateral stripes on one and two, and obscure brownish marks on the last two segments; anal appendages (Figs. 157, 158) consisting of short club-like superiors and broad inferiors with a tubercle on the dorsal margin.

Female.—Color, light blue (etain blue) or olive-buff, and black.

Head, with front, genae, and vertex pale blue or buff.

Thorax light blue or buff; pronotum blue and black, the propleura with indistinct noto-epimeral suture and without the dorsal marginal line of brown; median lobes of the notum with a large pale spot on each, and another spot about the same size covering the caudo-mesal angles of the median lobes and the median portion of the caudal lobe; mesostigmal plate (Fig. 154) with a short, median, acute process which projects caudad over the cephalic margin of the mesepisternum; mesepimera without the broad, longitudinal, dark stripe of the male, usually blue except the cephalic shoulder which is buff and frequently pollinose; all of the pleural sutures and the dorsal carina lined with black.

Abdomen black and blue, the black confined to rather broad dorsal stripes on terga 1–9, black spots on the caudo-lateral margins of 2–6 and the whole of sterna 1–8; segments nine and ten, with the exception of a dorsal brown stripe, and the lateral valves of the ovipositor yellowish; dorsal margin of the tenth tergum with a deep mesal emargination extending nearly to the base of the segment; superior anal appendages, short, dark, and scarcely longer than the blunt inferiors; ovipositor with broad ventrally serrated, lateral valves, the prostyles short and dark.

Measurements

Length, ♂	42 mm.
Length, ♀	41 mm.
Length of abdomen, ♂	33 mm.
Length of abdomen, ♀	31–32 mm.
Length of hind wings, ♂	26 mm.
Length of hind wings, ♀	26 mm.
Width of hind wings, ♂	5.5 mm.
Width of hind wings, ♀	5.5 mm.

Adults of this species have been taken at Oregon in Ogle County, at Mahomet in Champaign County, and at Muncie and Oakwood in Vermilion County, but the species is not especially abundant in any of these localities. The nymphs are reported by Needham ('03) as living under stones in swift currents and by Kellicott ('99) as living on the piles of docks in Lake Erie.

Argia sedula (Hagen)

Nymph.—Unknown.

Adult; Male.—Color, blue and black.

Head black and blue, the labium pale blue and buff; palpi narrow, the second segment dark and shorter than the fixed hook, the cleft of the median lobe obtuse at the base and shallow; postclypeus pale except a black transverse stripe along the dorsal margin; anteclypeus, labrum, exposed portions of the mandibles, a transverse area above the clypeus, and a spot latero-cephalad of each antenna blue; lateral ocelli with small yellow spots laterad of each, the remainder of the front and vertex being black; postocular blue spots large and contiguous with the margins of the compound eyes; occiput and postgenae, with the exception of rather narrow black stripes caudad of each postocular spot, yellowish buff.

Thorax: pronotum largely black, the median lobe with large subcircular spots and the caudal lobe with a pale spot on the extreme lateral angles, blue; proepimera and episterna blue; mesostigmal plates subtriangular, not projecting caudad; dorsal carina of the mesothorax covered by a broad black stripe which also covers about one-half of each mesepisternum and is followed by a broad blue stripe which covers the rest of the mesepisterna; the blue mesopleural stripe is wider adjacent to the mesostigma and is gradually narrowed caudad; the mesopleural suture is covered by a broad black stripe which also covers most of the mesepimera except the cephalo-ventral shoulders, and is considerably widened adjacent to the wing bases, enclosing a small blue spot; ventral half of the mesinfraepisterna yellow, the remainder black; metapleural suture with a narrow black line from wing bases to the metathoracic spiracles; remainder of the pleura and the postcoxal areas pale blue or buff; legs blue and black, the coxae pale, the trochanters black above, the femora black above and pale below, the front femora, however, with more or less black between the rows of setae; tibiae black below, pale above; tarsi dark brown, the claws bifid at the tip; wings with twelve to fourteen postnodal cross-veins in the front wing and eleven to twelve in the hind; M_2 arising between the sixth and seventh

postnodals in the front wing and between the fourth and fifth in the hind wing, usually nearer the fifth; stigma surmounting a single cell; paraptera dull velvety black.

Abdomen blue and black; basal half and a spot on the sides of the first tergum black, the remainder blue; dorsum and apex of the second black, the lateral margins blue; basal rings, and lateral marginal stripes, extending one-half to three-fourths the length of segments 3–6, inclusive, blue; the remainder of these terga, black; tergum seven except a small basal ring, black; dorsum of terga eight, nine, and ten blue, the lateral margins sometimes darker; first sternum with a black, median spot, 3–10 entirely black; anal appendages short, black, the inferiors longest and bifurcate (Figs. 149, 150).

Female.—Color, brown and black.

Head: front, vertex, occiput, and postgenae dull brown.

Thorax brown, the mesostigmal plates usually black and the caudal margins forming a thin blade which projects dorsad; black spots present on the mesopleural and metapleural sutures adjoining the wing bases; legs similar to the male except that the hind pair are almost entirely pale brown.

Abdomen dull brown, with indistinct touches of blue, very similar to that of the male except that the basal rings are not as broad or as well defined; terga 6–10, inclusive, entirely dull brown; anal appendages short; ovipositor long and slender, extending caudad of the anal appendages, pale brown in color.

Measurements

Length, ♂	30–40 mm.
Length, ♀	34 mm.
Length of abdomen, ♂	24–27 mm.
Length of abdomen, ♀	27 mm.
Length of hind wings, ♂	18–19 mm.
Length of hind wings, ♀	21 mm.
Width of hind wings, ♂	4–4.5 mm.
Width of hind wings, ♀	5 mm.

Described from a large series of males and females in the collection of Mr. E. B. Williamson.

This species has been reported from Illinois.

ARGIA TIBIALIS (Rambur)

Nymph.—Color, very dark brown.

Head about as long as broad, pentagonal; eyes black; antennae with all segments except the last two dark on the basal three-fourths,

the remainder pale; third antennal segment longest, the second and fourth about equal, and the first, fifth, sixth, and seventh successively shorter; caudo-lateral margins of the head without heavy setae; labium, when folded, extending caudad between the first and second pair of coxae; median lobe nearly as broad as long, and with about twelve marginal setae; lateral setae of the labial palpi two or three.

Thorax about as broad as long; legs with conspicuous brown bands, the femora possessing two—a broad basal one and a narrower preapical one—the tibiae three, one on base, one on apex, and a broader one just proximad of the middle; tarsi with the usual ventral setae and mostly dark; metathoracic wing-cases reaching the apex of the fifth abdominal segment in mature nymphs.

Abdomen dark, almost black; lateral keels feebly developed, hairy; dorsum of the first to the tenth terga with a pale mesal stripe which widens slightly caudad though not as conspicuously as in the nymph of *violacea* or *apicalis;* gills elliptical, sometimes wholly dark, or smoky, often possessing a broad, transverse, whitish band about the middle and a narrower subapical one; margins densely pilose but without heavy setae and the gills frequently coarsely spotted; female ovipositor extending to the apex of segment ten.

Measurements

Length	12.5 mm.
Length of abdomen	7 mm.
Length of gills	6.5 mm.
Width of gills	3 mm.
Length of metathoracic wing-cases	3.5 mm.
Length of median lobe	2.5 mm.
Width of median lobe	1.25–2 mm.

Adult; Male.—Color, dark purple or warm brown, sulphur-yellow, and black.

Head blue or brown; median lobe of the labium brown, the median cleft short, obtuse at the base; proximal segment of the palpus rather narrow, the apical segment black and slightly shorter than the black fixed hook; antennae black with the exception of the apices of segments one and two, which are pale; fronto-clypeal suture lined with brown; clypeus, labrum, exposed portions of the mandibles and their trochantins, genae, and front to the level of the median ocellus brown or blue; ocellar triangle, vertex, and the occiput, black, the black area sending a black stripe ventrad from the vertex to each antenna, and another enclosing the median ocellus and extending a short distance

ventrad where it meets a short transverse black line at right angles; clypeus and labrum, front and vertex, thinly pilose, the setae whitish; compound eyes slate-colored.

Thorax brown or purple and black; pronotum with black caudal lobe; median and cephalic lobes also black, the median lobes each with a small lateral brown spot; proepimera brown, with a broad black stripe above; mesostigmal plates black; dorsal carina covered by a black stripe, the lateral halves of the stripe covering about one-fifth of each mesepisternum, the stripes widened at the caudal and cephalic ends and covering the stigmal plates and paraptera; mesopleural suture covered with a broad black stripe which is frequently forked near the wing bases, extends cephalad, and covers all of the mesinfraepisterna except the caudo-ventral angles and one-third of each mesepimeron; metapleural suture with a narrow line of black, the metepisterna and epimera brown or buff; postcoxal areas buff, but frequently with darker lateral margins and a pair of median spots on the intersternum; legs mostly black, the coxae yellowish, with black cephalic surfaces, the femora black with the exception of the dorsal carinae which sometimes have a pale stripe; tibiae with a paler dorsal line; tarsi and claws black; anterior femoral setae eight or nine in the cephalic row, two large and usually two small ones in the caudal row; wings clear, the postnodal cross-veins twelve to thirteen in the hind wing and fifteen to sixteen in the front; M_2 arising between the seventh and eighth postnodal cross-veins in the front wing and between the sixth and seventh in the hind wing.

Abdomen black, with sulphur-yellow and blue; terga 1–8, inclusive; black, the yellow confined to lateral spots, narrow basal rings on 2–7, an apical ring on one, and narrow lines on the lateral margins of terga 2–7 which extend about one-half the length of each segment from the base and unite with the basal rings in segments three, four, and five; in older specimens, however, the lateral stripes are obscured by more or less brown; dorsum of the eighth and ninth terga, with the exception of the black apical margin of nine, pale blue; anal appendages (Figs. 155, 156) black, the superiors small and black, the inferiors black but with a paler dorsal spot.

Female.—Color, pale blue (pale methyl-blue) or buff (ochraceous buff), and black.

Head as in the male but lighter in color, the front lacking the vertical lines above the antennae and the transverse line below the median ocellus; postocular spots present and a pale transverse line, with more or less yellow, on the caudo-dorsal margins of the head; postgenae with yellow adjacent to the compound eyes.

Thorax blue or brown and black; caudal and cephalic lobes of the pronotum with more or less blue or brown; mesostigmal plates (Fig. 140) without projections on the caudal margins; mesopleural stripe of black, somewhat narrower than that of the male, separating more distinctly from the suture at the caudal third, the ventral branch frequently stopping short of the caudal margin of the sclerite; legs paler than those of the male, the femora usually with two dark stripes one on each side of the carina, the remainder pale blue or brown; tibiae with a black ventral stripe between the rows of setae which frequently includes one of the rows; tarsi often with the proximal segments pale.

Abdomen: lateral surfaces, apical ring, and narrow mesal lines of the first tergum pale, the black confined to two dorsal basal spots; second tergum with broad lateral blue stripes and a dorsal stripe greatly contracted and then widened again shortly before the apex, the black limited to a narrow apical ring and a dorso-lateral stripe on each side; segments 3–7 as in the male with the exception of a narrower mid-dorsal pale line; tergum nine black with a paler narrow apical line, the tenth yellowish or blue, with a narrow basal ring, the segment usually dark below; anal appendages of the usual type, the superiors black or dark, the inferiors slightly paler in color; ovipositor, except the extreme tip and the prostyles, dark brown or black.

Measurements

Length, ♂	34–37 mm.
Length, ♀	35–37 mm.
Length of abdomen, ♂	26–30 mm.
Length of abdomen, ♀	28 mm.
Length of hind wings, ♂	20–22 mm.
Length of hind wings, ♀	24 mm.
Width of hind wings, ♂	4.5 mm.
Width of hind wings, ♀	5 mm.

The nymphs of this species have been taken beneath rocks in swift currents. A single specimen has been reared and a comparison of the nymph with the nymph of *apicalis* shows them to be almost identical. Needham ('03) separates the two species on the character of the lateral setae, but there is so much variation in *apicalis* that the character seems without value.

The adults are common throughout the state and may be found at almost any point along the banks of clear, swift streams.

Argia violacea (Hagen)

Nymph.—Color, very dark brown.

Head pentagonal, the caudo-lateral angles nearly rectangular and provided with a few weak setae; antennal segments all dark except the proximal one, which is light in color; third segment longest and the second longer than the first; labium short and broad, the width about two-thirds the length; lateral setae two or three.

Thorax short, dark brown, with a black stripe on each side; legs with dark coxae and trochanters, a narrow proximal ring on each femur which is followed by two broad brownish rings, the three dividing the femur into fourths; tibiae with narrow proximal rings and rings of similar size shortly before the middle, the apices dark; tarsi dark, though not as dark as the rings of the femora and tibiae.

Abdomen dark brown with a paler mesal stripe on the dorsomeson; lateral keels feebly developed and without setae on their lateral margins; gills ovate, more than half as broad as long, uniform brown or sometimes having paler V-shaped marks near the apices, the margins thickly covered with setae arranged irregularly; ovipositor of the female with sharply pointed lateral valves which extend beyond the tenth abdominal segment.

Measurements

Length	17 mm.
Length of abdomen	7 mm.
Length of gills	4.5 mm.
Width of gills	2.5 mm.
Length of metathoracic wing-cases	5 mm.
Length of median lobe	3 mm.
Width of median lobe	1.25–2 mm.

Adult; Male.—Color, dark brown or purple (Matthew's purple).

Head: median lobe of the labium pale; distal segment of the labial palpi black at the tip; antennae black or dark brown except the basal segment, which is buff; clypeus and labrum pale brown, the front, vertex, and postocular regions also largely pale but becoming violet with age, the black confined to a broad transverse band embracing the two lateral ocelli, a T-shaped mark ventrad of the median ocellus, and narrow lines extending from the ends of the transverse band to the compound eyes and to the caudal margins of the head; caudo-dorsal margins of the head with a black line; occipital and postgenal regions largely yellow; compound eyes, slate-gray.

Thorax brown or violet and black; caudal lobe of the pronotum black and brown, the brown in lateral spots on the lateral margins and in a very small median spot; median lobes each with a large subcircular, lateral buff spot; proepimera buff, with dark lines marking the dorsal border; mesothorax with a black line on the dorsal carina and another just ventrad of the mesopleural suture and contiguous with the longitudinal portion of the suture for more than one-half its length; dorsal third of the mesinfraepisternum black; metapleural suture with a black line; metepimera and postcoxal areas buff; legs striped, all the femora with a black stripe on each side of the dorsal carina and the tibiae with a ventral stripe including one of the rows of setae; tarsi dark brown or black, the claws also black; wings clear, the stigma surmounting a single cell or less, the postnodal cross-veins of the front wing thirteen to fourteen, of the hind wing ten to eleven; M_2 arising between the fifth and sixth postnodal cross-veins in the front wing and between the fourth and fifth in the hind wing.

Abdomen purple and black, or brown and black; first tergum with a narrow, basal, black, transverse stripe, the second with large lateral spots extending from the cephalic margin nearly to the apex; terga three and four brown or purple, with the exception of a caudo-lateral spot on each side; tergum five with a dark apical ring and narrow lateral black stripes, the sixth with the purple confined to a dorsal stripe and a basal ring, the remainder of the tergum black or dark brown; seventh tergum entirely black, eighth, ninth, and tenth blue on the dorsum, black on the lateral surfaces; sterna 1–10 black; anal appendages (Figs. 145, 146) consisting of short blunt superiors and longer bifurcate inferiors.

Female.—Color, dark brown or dull violet.

Head similar to that of the male.

Thorax: dorsal mesostigmal plates (Fig. 142) with large rounded lobes at the caudo-mesal angles.

Abdomen with more black than the male; terga 2–9 with dorsolateral stripes which are broad enough on the seventh and eighth terga to fuse on the meson; lateral surface of tergum nine and all of ten buff, dorsal emargination of the tenth nearly reaching the base of the segment; anal appendages and ovipositor of the usual type, the lateral valves of the ovipositor being serrate on the ventral margin, the prostyles, dark.

Measurements

Length, ♂ .... 32 mm.
Length, ♀ .... 31 mm.
Length of abdomen, ♂ .... 24 mm.

Length of abdomen, ♀ ....20 mm.
Length of hind wings, ♂ ....20 mm.
Length of hind wings, ♀ ....20 mm.
Width of hind wings, ♂ ....4 mm.
Width of hind wings, ♀ ....5 mm.

This species is common at times along the Drainage Ditch north of Urbana, and the nymphs may be taken at almost any season in the black mud on the bottom of the stream. The species has not been collected elsewhere in the state and it does not seem to be as common as reported to be in Indiana. The nymphs emerge throughout June and the adults fly as late as the first of September.

Genus Enallagma Charpentier

The nymphs of this genus are characterized by the presence of three, rarely four, mental setae, and five lateral setae. The gills are variable but do not possess the long tapering points of Ischnura and Anomalagrion, being relatively blunt at the tip. The lateral keels are well developed and setose and in some cases present characters of diagnostic value for the species.

The adults in all cases have vein M_2 arising between the fourth and sixth, usually fourth and fifth, postnodal cross-veins in the front wing and between the third and fifth in the hind wing. The number of postnodal cross-veins varies from seven to twelve, and the female always has a long apical seta on the eighth sternum. The eighth sternites at the base of the cephalic pair of gonapophyses of the female are visible and are small and subtriangular.

The genus is represented in Illinois by more species than any other genus of Zygoptera.

Key to Species

nymphs

a. Gills without pigment except in the tracheae.
  b. Dark tracheal branches in alga-like patches (Fig. 76) ...... *hageni.*
  bb. Dark tracheal branches not in alga-like patches.
    c. Lateral keel of the first abdominal segment without setae; axis of the gills clear.
      d. Dorsal marginal setae of the median gill less than twenty in full-grown nymphs; all of the third antennal segment dark brown; gills rarely more than 4.5 mm. in length (Fig. 72) .... *geminatum.*

dd. Dorsal marginal setae of the median gill more than twenty in full-grown nymphs; only the proximal third of the third antennal segment dark brown; gills commonly 5.5–6 mm. in length. . . . . *civile.*

cc. Lateral keel of the first abdominal segment with two to four heavy setae; axis of the gills opaque or slightly smoky.

d. Dorsal setae of the median gill extending beyond the middle; mental setae four, the meso-caudal seta in each row one-half as long or nearly as long as the remaining setae. . { *cyathigerum.* / *calverti.* }

dd. Dorsal setae of the median gill not extending to the middle of the gill; mental setae three, the meso-caudal seta in each row representing a small fourth, but minute and always less than one-half the length of the three larger setae. *carunculatum.*

aa. Gills with pigment other than in the tracheae.

b. Tracheal branches of the gills in alga-like patches; distance from the caudal margins of the compound eyes to the caudo-lateral angles of the head greater than half the distance between the antennal fossae. Abdomen without a median, ventral, black line.

c. Dark portion of the base of the gills extending less than half their length (Fig. 55) . . . . *traviatum.*

cc. Dark portion of the base of the gills extending more than half their length.

d. Length of the gills less than eight times the greatest width; gills of mature nymphs with a prominent hinge just caudad of the middle (Fig. 53) . . . . *exsulans.*

dd. Length of the gills eight times the greatest width; gills of mature nymphs without a prominent hinge caudad of the middle (Fig. 54) . . . . *antennatum.*

bb. Tracheal branches of the gills not in alga-like patches; distance from the caudal margins of the compound eyes to the caudo-lateral angles of the head less than half the distance between the antennal fossae. Abdomen with a median, ventral, black line.

c. Median gill with a bunch of setae proximad of the first dark transverse cross-band; distal cross-bands of the same degree of blackness as the proximal ones (Fig. 56); median gill not greatly expanded distad of the first cross-band; dorsal setae of the apical margins of the abdominal terga not prominent. . . . . *signatum.*

cc. Median gill without a bunch of setae proximad of the first dark transverse cross-band; distal cross-bands faint, and lighter in color than the proximal ones (Fig. 57); median gill much expanded distad of the first cross-band; dorsal setae of the apical margins of the abdominal terga very prominent. . . . . . *pollutum.*

ADULTS

Females

a. Eighth abdominal tergum with a large blue or pale spot on each side side of the meson.

b. Dorsum of the seventh tergum black (Fig. 96) . . . . *geminatum.*

bb. Dorsum of the seventh tergum blue, never with more than a line of black on the meson (Fig. 95) . . . . *aspersum.*

aa. Eighth abdominal tergum without a large blue or pale spot on each side of the meson.

b. Longitudinal dark stripe on the dorsum of the second abdominal tergum dumb-bell shaped; caudal half of the eighth tergum black or dark . . . . *traviatum.*

bb. Longitudinal stripe on the second abdominal tergum not dumb-bell shaped; apical half of the eighth black or dark.

c. Proximal two-thirds of the second antennal segment pale.

d. Dark stripe of the mesopleural suture reduced in width to a mere line and much less distinct than the dorsal stripe covering the carina; color of the thorax above faint blue (teneral) or lemon-yellow (mature) and black . . . . *pollutum.*

dd. Dark stripe of the mesopleural suture not reduced in width to a mere line and as distinct as the dorsal stripe covering the carina; color of the thorax above blue (teneral) or orange (mature) and black . . . . *signatum.*

cc. Proximal two-thirds of the second antennal segment brown or black.

d. Dorsum of the tenth tergum dark; mesopleural black stripe of the suture not divided by a brown stripe immediately above the suture; caudal lobe of the pronotum without a median mound-like elevation.

e. M_2 arising beyond the fourth postnodal cross-vein in the hind wing.

f. Mesostigmal plates with a diagonal ridge from the caudo-mesal to the cephalo-lateral angles . . . . *carunculatum.*

ff. Mesostigmal plates without a diagonal ridge from caudo-mesal to cephalo-lateral angles.

g. Black color of dorsum of abdominal terga 4–7 always reaching the cephalic margins (Fig. 92).

h. Mesal half of the caudal margins of the mesostigmal plates convex (Fig. 212) . . . . *civile.*

hh. Mesal half of the caudal margins of the mesostigmal plates concave (Fig. 226) . . . . *doubledayi.*

gg. Black color of the dorsum of abdominal terga 4–7 never reaching the cephalic margins.

h. Cephalo-mesal angles of the mesostigmal plates rounded and hollowed out (Fig. 213) . . . *cyathigerum.*

hh. Cephalo-mesal angles of the mesostigmal plates not rounded or hollowed out (Fig. 223) . . . . *calverti.*

ee. M_2 arising between the third and fourth postnodal cross-veins in the hind wings.

f. Mesostigmal plates narrowed at middle (Fig. 227) . *ebrium.*

ff. Mesostigmal plates considerably widened at the middle (Fig. 221) . . . . *hageni.*

dd. Dorsum of the tenth tergum pale; mesopleural black stripe divided by a brown stripe immediately above the suture; caudal lobe of the pronotum with a median mound-like elevation (Figs. 219, 220).

e. Caudal margin of the mesostigmal plates at right angles to the dorso-meson . . . . *exsulans.*

ee. Caudal margin of the mesostigmal plates not at right angles to the dorso-meson . . . . { *antennatum.* *divagans.*

Males

a. Dorsum of the second abdominal tergum with an apical spot occupying at most half of the segment; remainder of the tergum blue.

b. Lateral surface of the second abdominal tergum with a short longitudinal brown or black stripe . . . . *geminatum.*

bb. Lateral surface of the second abdominal tergum without a short longitudinal brown or black stripe.

c. Caudal half of the seventh abdominal tergum blue; postocular spots connected with the blue of the occiput . . . . *aspersum.*

cc. Caudal half of the seventh abdominal tergum black; postocular spots not connected with the blue of the occiput.

d. Dorsum of the fourth and fifth abdominal terga more than half black . . . . *carunculatum.*

dd. Dorsum of the fourth and fifth abdominal terga less than half black.

e. Superior anal appendages bifurcate . . . . *ebrium.*

ee. Superior anal appendages not bifurcate.

f. Inferior anal appendages longer than the superiors.

g. M_2 arising between the third and fourth postnodal cross-veins in the hind wings . . . . *hageni.*

gg. M_2 arising between the fourth and fifth postnodal cross-veins in the hind wings.

h. Superior anal appendages blunt; lateral profile as shown in Fig. 200 .... *calverti.*

hh. Superior anal appendages acute; lateral profile as shown in Fig. 201 .... *cyathigerum.*

ff. Inferior anal appendages shorter than the superiors.

g. Superior anal appendages with the apical tubercles projecting noticeably beyond the dorso-caudal angles when viewed from the side (Fig. 175) .... *doubledayi.*

gg. Superior anal appendages with the apical tubercles not projecting noticeably beyond the dorso-caudal angles when viewed from the side (Fig. 198) .... *civile.*

aa. Dorsum of the second abdominal tergum wholly black.

b. Second antennal segment pale except the distal third, which is dark brown or black.

c. Dark stripe of the mesopleural suture paler in color than the dorsal stripe covering the carina and often reduced to a mere line .... *pollutum.*

cc. Dark stripe of the mesopleural suture not paler in color than the dorsal stripe covering the carina and never reduced to a line .... *signatum.*

bb. Second antennal segment entirely dark brown or black.

c. Front with the blue color extending dorsad to the median ocellus; postocular spots forming an equilateral triangle; black stripe of the mesopleural suture indistinct or wanting........ *traviatum.*

cc. Front with the blue or pale color not extending dorsad to the median ocellus, not dorsad of the antennal fossae; postocular spots forming a wedge-shaped figure; black stripe of the mesopleural suture distinct, never wanting.

d. Superior anal appendages bifurcate.

e. Dorsal arm of the superior appendages shortest; arms not widely divaricate (Figs. 203, 210) .... *exsulans.*

ee. Dorsal arm of the superior appendages as long as the ventral; arms widely divaricate (Figs. 202, 209) .... *antennatum.*

dd. Superior anal appendages not bifurcate (Figs. 190, 197) .... *divagans.*

Enallagma antennatum (Say)

Nymph.—Color, brown or greenish.

Head about half as long as wide, the caudo-lateral angles projecting strongly caudad and thickly studded with setae; second antennal segment slightly shorter than the first, the first two segments dark and pilose; labium with three mental setae, four or five lateral ones, and

with seven or eight setae on the lateral margins of the median lobe; labium extending just caudad of the first pair of coxae.

Thorax about half as wide as the head; the femora all with preapical rings on the distal third; tibiae with the usual apical scales; tarsi pale; metathoracic wing-cases extending beyond the cephalic margin of the fourth abdominal segment.

Abdomen slender, the lateral keels well developed on segments 1–8 but almost wholly lacking in setae except the seventh, which sometimes possesses a single weak one; gills (Fig. 54) long and slender, somewhat lanceolate, with a gradually tapering tip; the smaller tracheae are collected in alga-like patches, and the gills are always provided with some dark cuticular pigment; there is a light spot on the apical third or fourth of the gill on each side of the axis as in *exsulans* which is often followed by two dark cross-bands, the extreme tip, however, being light in color; female ovipositor extending to the middle of the tenth sternum.

Measurements

Length	13–14 mm.
Length of abdomen	9 mm.
Length of gills	7–8 mm.
Width of gills	1–1.3 mm.
Length of metathoracic wing-cases	4 mm.
Length of median lobe	1.6 mm.
Width of median lobe	.5–1.2 mm.

The nymph is very similar to *exsulans* but may be distinguished from that species by means of the more slender gills, the cross-bands at the tip in older individuals, and by the absence of a hinge beyond the middle.

Adult; Male.—Color, blue or greenish yellow and black.

Head black and orange; mouth-parts buff, the median lobe of the labium subtriangular, the median cleft shallow, acute; proximal segment of the palpus comparatively narrow, the apical half of the distal segment dark; antennae dark, the apex of the first two segments sometimes lighter in color; a large portion of the postclypeus and a dorsomesal spot on the labrum, black; anteclypeus, the remainder of the labrum, exposed portions of the mandibles, their trochantins, the genae, and a transverse stripe above the clypeus orange; remainder of the front and vertex dull black; postocular spots cuneiform, connected with the narrow stripe of the caudo-mesal margin; occiput and postgenae yellow except a black stripe caudo-ventrad of the postocular spots; compound eyes slate-gray.

Thorax yellow or blue, and black; pronotum blue and black, the cephalic lobe largely blue, the median lobes black with small lateral blue spots and with median spots, but only in very recently emerged specimens; caudal lobe of the pronotum with a small, pale, mesal spot, the remainder black; mesostigmal plate with a pale lateral spot and a smaller spot on the caudo-mesal angle; dorsal carina lined with blue, on each side of which there is a broad black stripe occupying about half or more of each mesepisternum; beyond these dorsal stripes on the mesepisterna there are narrow, pale stripes; mesopleural suture covered by a broad black stripe which extends cephalad onto the mesinfraepisternum and covers one-third of it; interpleural fold with a black dash near the wing bases; remainder of the thorax pale greenish yellow.

Abdomen black, greenish yellow, and blue; terga 1–8, inclusive, and ten with black dorsal longitudinal stripes, the stripes widened subapically on segments 2–5, inclusive, and narrowed to the meson at the apex of eight; apical black rings on terga 2–5 and on eight; lateral surfaces of terga 1–8, inclusive, with basal interrupted rings except on the first, which has an apical pale yellowish green ring; lateral surface of the eighth tergum and all of the ninth blue; sterna 2–8 with a black ventral mesal line; superior anal appendages (Figs. 202, 209) black, bifurcate, the arms about equal and widely divaricate; the inferiors shorter, directed obliquely dorsad, mostly buff, the tips black.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax similar in color to that of the male; prothorax with a small spot on each median lobe near the meson, besides the lateral ones, and the mesopleural black stripe more commonly divided by a brown line immediately over the suture.

Abdomen: terga 1–10 with broad dorsal brown or black stripes, the stripes widened subapically on segments two to six and continuous with a dark apical ring on the same segments; tergum nine with a narrow pale line, sometimes diamond-shaped; lateral surfaces of terga 2–7 inclusive, greenish yellow; sterna 1–7 or 1–8 with a black mesal line; eighth sternum with a very long and heavy apical seta and the anal appendages of the usual type; ovipositor including the prostyles not extending caudad of the anal appendages, the ventral margins of the lateral valves serrate; eighth sternites small, triangular.

Measurements

Length, ♂ ....34 mm.
Length, ♀ ....32 mm.

Length of abdomen, ♂ ....28 mm.
Length of abdomen, ♀ ....25 mm.
Length of hind wings, ♂ ....19 mm.
Length of hind wings, ♀ ....19 mm.
Width of hind wings, ♂ ....4 mm.
Width of hind wings, ♀ ....4 mm.

A relatively rare species which has not been collected outside of Champaign County. The nymphs are to be found in the same locality where *exsulans* is abundant and the two are frequently taken together.

ENALLAGMA ASPERSUM (Hagen)

Nymph.—Unknown.

Adult; Male.—Color, blue and black.

Head blue and black; mouth-parts buff, the median lobe subtriangular and with a shallow acute cleft; palpi narrow, the distal segment pale; antennae black; postclypeus black, anteclypeus and the labrum brown or buff and a blue transverse stripe above the clypeus to the level of the antennal fossae; remainder of the front and vertex black; postocular spots blue, the blue connected with the blue of the occiput and postgenae.

Thorax blue and black; pronotum black except the narrow cephalic lobe, which is blue; proepimera black above, blue or pale below; mesostigmal plate narrow and about half blue; mesothorax with a broad dorsal stripe, covering the carina and also half of the mesosupraepisterna on either side; this is followed by a blue stripe which occupies most of the remaining portion of the mesosupraepisternum; mesopleural suture covered with a black stripe which is considerably widened near the caudal margin of the mesinfraepisternum and extends cephalad over that sclerite, covering the dorsal half or third; remainder of the thorax blue or buff; paraptera entirely black; legs black and buff, the coxae and the trochanters pale, the femora with a stripe on the cephalic surfaces including one row of setae; tarsi and claws black, shining; wings with nine postnodal cross-veins in the front wing and eight in the hind wing; M_2 arising between the fourth and fifth postnodal cross-veins in the front wing and between three and four in the hind wing.

Abdomen blue and black; terga mostly blue, but a very narrow basal spot on the first tergum, a dorsal apical spot and ring on the second, the apical three-fourths of the dorsum of the third, dorsum of the fourth, all of five and six except narrow basal rings, the proximal half of seven, and all of the dorsum of ten, are black; lateral margins

of the fourth, fifth, and sixth terga are mostly pale yellow; anal appendages (Fig. 195) black, the superiors much longer than the inferiors and with a ventral basal tubercle, the apices blunt and directed ventrad; inferiors conical, sharply pointed, and directed obliquely dorsad.

Female.—Color similar to that of the male.

Head similar to that of the male except that the postocular spots are not connected with the blue of the caudal portion of the occiput.

Thorax similar to that of the male; mesostigmal plates black.

Abdomen (Fig. 95) with terga 1–6 as in the male, seven with dorsal stripe reduced to a mesal line on the basal three-fourths, suddenly widened at the apex; eighth tergum black, with a pair of pale basal spots connecting with the pale lateral margins; dorsum of nine and ten black, the lateral surfaces pale; ovipositor short, the prostyles blunt and dark, the ventral margins of the lateral valves serrate.

Measurements

Length, ♂	27–32 mm.
Length, ♀	34 mm.
Length of abdomen, ♂	22–25 mm.
Length of abdomen, ♀	26 mm.
Length of hind wings, ♂	16–18 mm.
Length of hind wings, ♀	20 mm.
Width of hind wings, ♂	3–3.7 mm.
Width of hind wings, ♀	4 mm.

Described from a specimen taken at Lexington, Ky., August, 1915, and a number of both sexes in the collection of E. B. Williamson.

Reported from Illinois.

Enallagma calverti Morse

Nymph.—Color, buff.

Head subelliptical, the caudo-lateral margins projecting a little caudad and with a few setae; antennae of the usual form, the third segment longest, the second longer than the first; labium extending caudad to the second pair of coxae; mental setae four, lateral setae six, and the marginal setae on the margin of the median lobe five or six.

Thorax: legs with rows of heavy setae, especially prominent on the femora, which have several rows and a group of longer setae near the apices; tibiae with two ventral rows of long setae, and a thick bunch of scales at the apices; tarsi of the usual form and with thick ventral

rows of setae; metathoracic wing-cases extending caudad to the middle of the fourth abdominal segment.

Abdomen long and slender, uniform buff, the cuticle provided with minute setae; segments 3–10 with dorsal transverse rows of setae at the caudal margins and segments 3–7 with similar ventral rows, the setae grouped somewhat conspicuously on the meson; lateral keels strongly developed, setose, the keel of the first segment with a number of heavy setae, usually three, that of the second with a row of eight or nine, and keels of the third to the eighth segments with a row of ten or twelve, and with groups of two or three at the apices; ninth segment with a lateral row of setae in line with the lateral keels; gills (Fig. 80) very long, somewhat spatulate, the points mostly blunt, and the dorsal marginal row of setae of the median gill extending much beyond the middle; three narrow transverse bands sometimes occur just beyond the middle; they are placed closely together as a rule, but the bands may be reduced to one or may be wanting.

Measurements

Length	15 mm.
Length of abdomen	9 mm.
Length of gills	7 mm.
Width of gills	1.8 mm.
Length of median lobe	2.3 mm.
Width of median lobe	.8–1.6 mm.

Described from three specimens in the collection of the State Laboratory of Natural History, collected at Havana, Ill., June 30, 1897.

The nymph has not been reared, but the specimens were determined from a description given by Walker.

Adult; Male.—Color, blue and black.

Head blue and black, buff below; labium buff, the median lobe subtriangular, the apical cleft narrow; distal segment of the labial palpi pale; postclypeus black except the lateral margins, anteclypeus, labrum, mandibles, their trochantins, genae, and the transverse area above the clypeus blue; lateral ocelli with a small blue spot cephalad of each, the remainder of the front and vertex black; pale line caudad of the ocellar area distinct, the ends narrowly separated from the large blue, cuneiform postocular spots; occiput pale except a transverse black line bordering the postocular spots.

Thorax blue and black; pronotum mostly black, with a large blue spot on each median lobe, the caudal margin of the caudal lobe and

most of the cephalic lobe blue; proepimera blue, the dorsal border with a broad black stripe; mesothorax with a blue dorsal carina, the black stripe on each side occupying about half of each supraepisternum; mesopleural suture covered by a black stripe which is suddenly widened caudad of the infraepisterna; dorsal third of the mesepimeron black; metapleural suture with a black spot adjacent to the wing bases; paraptera black, the cephalic margins blue; remainder of the pleura blue; postcoxal areas buff; legs striped black and blue, the coxae largely blue; trochanters blue, dark above; femora with black stripes occupying the whole of the dorsum, but not extending ventrad far enough to include either row of setae; cephalic margins of all femoral black stripes emarginate at the proximal end; cephalic half of the tibiae black, the stripe including the cephalo-ventral row of setae; tarsi uniform brown, the segments darker at the distal end; wings with 12–13 postnodal cross-veins in the front wing and 10–11 in the hind; M_2 arising between the fifth and sixth postnodal cross-veins or near the fifth in the front wing, and between the fourth and fifth in the hind; stigma small, pale brown, and surmounting slightly less than a single cell.

Abdomen blue and black; terga 1–5 inclusive, blue with the exception of a black spot on the dorsum of one, a subapical dorsal spot and apical ring on two, and apical spots and rings on 3–5; caudal half of the dorsum of six and caudal three-fourths of seven, black; terga eight and nine blue; tenth tergum black above, pale buff on the lateral margins; first sternum pale; sterna 3–8 black; parameres black and not reaching the apex of the segment; anal appendages short (Figs. 200, 207), the superiors blunt, shorter than the inferiors, but without the conspicuous tubercle of *civile* and *carunculatum;* inferiors slender, acute and black at the tips.

Female.—Color, blue, but paler than that of the male.

Head: the blue of the male is replaced by brown or buff.

Thorax similar to that of the male, but the blue is frequently replaced by brown or buff.

Abdomen blue and black, the first tergum with a black basal spot as in the male, spot of the second tergum connected with the apical ring and a line on the meson extending to the base of the sclerite; terga 3–6 with narrow dorsal black lines widened suddenly near the apices of the segments and occupying the caudal three-fourths; seventh tergum with a similar but broader dorsal line; caudal half of the dorsum of the eighth, and all of the ninth and tenth black; lateral margins of all terga pale; sterna 3–7 black; one, two, eight, and ten pale; ovipositor pale, the lateral valves broad.

Measurements

Length, ♂	33–35 mm.
Length, ♀	34 mm.
Length of abdomen, ♂	26 mm.
Length of abdomen, ♀	26 mm.
Length of hind wings, ♂	19 mm.
Length of hind wings, ♀	21 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4–4.5 mm.

This species is closely related to *carunculatum, civile, doubledayi,* and *cyathigerum.* The adult male is easily distinguished from those species by means of the anal appendages; the female, less easily, by means of the mesostigmal plates.

Illinois is within the range of the species and it probably occurs within the state although there seems to be no record of its presence.

A large number of adults of both sexes have been examined, all in the collection of Mr. E. B. Williamson.

Enallagma carunculatum Morse

Nymph.—Color, green or buff.

Head about twice as broad as long, the caudo-lateral margins not projecting strongly, but with a few strong setae; antennae with the third segment longest, the second longer than the first, the first two and the proximal portion of the third darker than the rest; mental setae of the median lobe three, and sometimes a small fourth on each side; lateral setae six; marginal setae of the median lobe eight or nine on each side; labium extending caudad between the first and second pair of coxae.

Thorax: legs pale, the femora with very faint or no preapical rings and distinct rows of moderately heavy setae; tibiae and tarsi with the usual apical scales and ventral setae; metathoracic wing-cases extending about to the middle of the fourth abdominal segment.

Abdomen with well-developed lateral keels, the keel of the first segment with three or four setae; the second, with eight to twelve; third, with about eleven; fourth, with thirteen to fifteen; fifth, eighteen to twenty; sixth, eighteen to twenty; seventh, twelve to fourteen; and the eighth with about fourteen; on the fifth and sixth keels the setae are bunched at the apex, with sometimes as many as three together; venter of the abdomen entirely without small setae on the cephalic segments, but usually with long hair-like setae on the dorsum of segments

two, three, and four. In mature nymphs there is an indefinite, dark dorsal stripe extending from near the apex of the third segment to the seventh or eighth; gills (Fig. 70) transparent, lanceolate, with a broad, usually pale, opaque stripe along the axis from the base to near the tip; dorsal marginal setae of the median gills usually more than twenty in number and extending one-third the length of the gill from the base, the ventral setae of the same gill consisting of only a few setae and extending half as far as the dorsal row; ventral marginal setae of the lateral gills of similar extent to the dorsal setae of the median gill; apical margins usually without setae or hairs; ovipositor of the female extending to the middle of the tenth abdominal segment and the lateral valves with about four heavy setae on the ventral margin.

Measurements

Length	13.5–14 mm.
Length of abdomen	8–9 mm.
Length of gills	5.5–6 mm.
Width of gills	1.2 mm.
Length of metathoracic wing-cases	3.6 mm.
Length of median lobe	2.5 mm.
Width of median lobe	.5–2 mm.

Adult; Male.—Color, dark blue or buff and black.

Head blue or buff and black, the labium buff, the median lobe subtriangular, the palpus moderately narrow; antennae entirely black, the first segment paler at the apex; postclypeus with a large, shining black spot, the ventro-lateral margins pale; anteclypeus, and labrum except a dorso-mesal black spot and a dorso-lateral spot on each side, pale; exposed portions of the mandibles, their trochantins, the genae, and a transverse stripe above the clypeus, pale; remainder of the front and vertex dull black; postocular spots oval, buff or blue, and not usually connected with the stripe caudad of the ocellar area; occiput and postgenal regions pale except a black stripe caudo-ventrad of the postocular spots.

Thorax blue or buff and black, the pronotum dull black with a transverse median stripe on the cephalic lobe, the caudal margin of the caudal lobe and small crescentic spots on the lateral margins of the median lobe buff or blue; dorsal third of the proepimera black, the dorsal suture indistinct, the remainder of the sclerite buff or blue; cephalo-lateral angles of the mesostigmal plates elevated, the elevated portion pale; pale stripe of the mesosupraepisternum regular, the margins parallel and straight, the stripe extending from the cephalic margin

nearly to the paraptera; black stripe of the mesopleural suture widest just caudad of the mesinfraepisternum, extending onto and covering about the dorsal third of that sclerite, the stripe continuous at the caudal extremity with a narrow stripe extending ventrad along the caudal margin of the mesepimeron to the interpleural fold; metapleural suture with a black spot adjacent to the wing bases; remainder of the thorax buff or blue; legs striped, buff and black, the coxae and trochanters usually pale, the femora with broad dorsal stripes from bases to apices; tibiae with dorsal stripes covering about half the dorsal surface and including the cephalo-ventral row of setae; tarsi and claws pale, black at the tips, the claws very long; wings with nine to eleven postnodal cross-veins and with M_2 arising near the fifth postnodal cross-vein in the front wing and between four and five in the hind wing.

Abdomen black and blue or buff; terga 1–6, inclusive, blue or buff, except a small black basal spot on one, a black apical ring and dorsal spot occupying half the second and third terga, another covering slightly more than half the fourth, two-thirds of the fifth and sixth, and all of the seventh except the narrow lateral marginal stripes and a basal ring; dorsum of the tenth tergum black; eighth and ninth terga entirely blue or buff; sterna one and 3–8 with a median black line; anal appendages (Figs. 194, 205) short, the superiors usually black, blunt, and with a narrow notch on the dorsum cephalad of but near the dorso-caudal angle; inferiors paler, the black apices directed strongly dorsad and frequently in contact with the superiors.

Female.—Color similar to that of the male.

Head similar to that of the male; the postocular spots are, however, considerably smaller.

Thorax similar to that of the male.

Abdomen with the dorsum of terga 1–10 with broad, dorsal dark stripes, widened subapically on segments 2–4 inclusive, the pale color occupying the larger part of the lateral surfaces of all terga as lateral stripes which are continuous with the broad uninterrupted basal rings on segments 4–7 and the interrupted ring of the third tergum; sterna 1–8 with a mesal black line from the bases to near the apices, the eighth sternum with a long apical seta; lateral valves of the ovipositor broad, pale, the ventral margins serrate from apex nearly to base, the pro-styles darker on the apical half.

Measurements

Length, ♂ ....33 mm.
Length, ♀ ....32 mm.

Length of abdomen, ♂ ....26 mm.
Length of abdomen, ♀ ....25 mm.
Length of hind wings, ♂ ....19 mm.
Length of hind wings, ♀ ....19 mm.
Width of hind wings, ♂ ....4 mm.
Width of hind wings, ♀ ....4 mm.

An inhabitant of the lake regions of Illinois, the nymphs preferring floating vegetation or rank growth along the banks of ponds or lakes of considerable size, though they are occasionally to be encountered in the larger and clearer streams.

The color of the recently emerged adult is buff or cream-color and black, and the blue is much slower in appearing than in other species.

Enallagma civile (Hagen)

Nymph.—Color, green or buff.

Head about twice as broad as long, the caudo-lateral angles not projecting caudad or laterad, but armed with short setae; antennae with the third segment longest, the first shorter than the second, the first two segments and the proximal portion of the third dark brown, the remainder of the third and the distal segments pale; labium extending just caudad of the first pair of coxae, the median lobe with three or four mental setae, the labial palpi with five or six lateral setae and a row of seven or eight small setae on the margin of the median lobe.

Thorax pale buff or green; legs very pale, the preapical femoral rings indistinct, the femora with a dorsal and lateral row of setae and scales near the tips; metathoracic wing-cases extending caudad to the middle of the fourth abdominal segment.

Abdomen pale buff or green, frequently with an indefinite darker stripe on the dorsum of segments 3–7, the cuticle sparsely provided with minute setae, which are usually lacking on the venter of the cephalic segments; dorsum of two, three, and four with long hair-like setae; lateral keels well developed and setose, the first without setae, the second with a row of about eleven, the third with twelve, the fourth with sixteen, fifth with eighteen to twenty, sixth with fifteen to sixteen, seventh with twelve to fourteen, and the eighth with a straight row of about nine setae; gills (Fig. 75) lanceolate, colorless and usually without pigment except in the smaller tracheae, the margins very transparent; dorsal marginal setae of the median gill extending less than half the length of the gill from the base, and composed of more than twenty setae; ventral row of the lateral gills slightly longer

and about half the length of the gills; female ovipositor extending to the middle of the tenth abdominal segment, the ventral margins of the lateral valves setose, the row consisting of about eight stout setae and a number of hair-like ones.

Measurements

Length	15 mm.
Length of abdomen	10 mm.
Length of gills	6 mm.
Width of gills	1.8–2.1 mm.
Length of metathoracic wing-cases	4.5 mm.
Length of median lobe	3.1 mm.
Width of median lobe	.8–2.3 mm.

Adult; Male.—Color, dark blue and black.

Head blue and black; mouth-parts buff, the median lobe of the labium subtriangular, with a shallow, acute, median cleft, the labial palpi much broader at the proximal end than at the apex; antennae dark brown or black; postclypeus with a shining black spot on the meson; anteclypeus shining yellow; labrum shining yellow with a black dorso-mesal spot; exposed portions of the mandibles, trochantins, and genae pale, and a pale stripe above the clypeus extending dorsad to the level of the antennal fossae; remainder of the front and vertex dull black; postocular spots oval or subcuneiform, the pale line caudad of the ocellar area not distinct; occiput and postgenae yellow, except a transverse black stripe caudo-ventrad of the postocular spots; compound eyes dark brown or black.

Thorax blue and black, the black usually metallic; pronotum black, the cephalic lobe with a pale transverse line, the median lobe with a pale spot on the lateral margins and the caudal lobe also with pale margins; proepimera with black dorsal borders, pale below; mesostigmal plates subquadrangular, the cephalo-lateral angles somewhat elevated, though not as much so as in *carunculatum*, and the lateral half covered by a yellow spot; dorsal black stripe regular and covering nearly half of each supraepisternum; pale stripe of the supraepisterna broadest dorsad of the mesinfraepisterna, extending nearly to the paraptera; mesopleural black stripe of the suture narrowed cephalad of the wing bases, broadest shortly caudad of the mesinfraepisterna and extending across and covering about one-third of the latter; caudal margin of the mesepimera black to the level of the interpleural suture; metapleural suture with a black spot cephalad of the wing bases; remainder of the pleura blue, the postcoxal areas buff, becoming pollinose; paraptera black, the cephalic margins pale and a pale spot below the lateral angles; legs striped, the coxae and trochanters pale, the

femora with stripes on the dorsum, the tibiae with black stripes occupying half the dorsa, but not reaching the apices of the segments; tarsi and claws pale, dark at the tip, the claws notched at a considerable distance proximad of the tip; wings with nine or ten postnodal cross-veins, the vein M_2 arising between the fourth and fifth postnodal cross-veins, usually near the fifth, in the front wing, and between the fourth and fifth in the hind wing.

Abdomen blue and black, the cephalic terga largely blue, the caudal ones darker and frequently becoming pollinose with age; terga 1–6, inclusive, blue except a small basal spot on the dorsum of one and black shield-shaped apical spots and apical rings on 2–6; dorsal black spot of the sixth tergum occupying about half the dorsum, those of 2–5 about one-fourth; dorsum of the seventh and tenth terga black except the lateral margins and a narrow, basal, interrupted ring on the seventh; all of the eighth and ninth terga blue; sterna 2–10 with a black median line; anal appendages (Figs. 198, 103) short, the superiors blunt, with a narrow cleft or notch just ventrad of the apex; inferiors usually black and shorter, the black tips directed obliquely caudad and dorsad and frequently in contact with the superiors.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax similar to that of the male except in the color of the legs, which are usually lighter, the dorsal stripes of the femora never extending to the proximal ends of those segments.

Abdomen: the dorsum of all terga have a black longitudinal stripe from the bases to the apices and a short, narrow, apical, black ring; margins of all terga yellow or blue, the pale color extending onto the dorsum at the bases of segments 2–6, but always forming interrupted rings and never connected across the dorsum (Fig. 92) as in *carunculatum* (Fig. 91); sterna 1–8 with a mesal line from bases to apices, the apex of the eighth sternum with a heavy seta which is darker at the tip than at the base; anal appendages of the usual form, the ovipositor with yellow lateral valves, the ventral margins of which are serrate from the apex to near the base; prostyles brown, dark at the tip.

Measurements

Length, ♂	29–32 mm.
Length, ♀	30–32 mm.
Length of abdomen, ♂	23–24 mm.
Length of abdomen, ♀	23–24 mm.
Length of hind wings, ♂	17 mm.
Length of hind wings, ♀	19–20 mm.
Width of hind wings, ♂	3.5–4 mm.
Width of hind wings, ♀	3.5–4 mm.

A common species at Urbana. It was not taken at Havana, where *carunculatum* was abundant, nor at Lake Villa, where both *carunculatum* and *hageni* were common. The females of these closely allied species have been determined from material collected in the above localities. A study has also been made of specimens taken in copula, in the collection of Mr. E. B. Williamson.

The imago emerges at Urbana as early as June 13 and apparently continues to emerge throughout the season. Nymphs taken late in July emerged shortly after, and another lot, collected at Lexington, Ky., emerged as late as August 18, 1915. There is a possibility that the species has two broods a year.

Enallagma cyathigerum (Charpentier)

Nymph.—Color, buff.

Head elliptical, the caudo-lateral angles rounded and sparsely setose; antennae of the usual form, the second segment slightly longer than the first; labium broad, and extending caudad to the mesocoxae; mental setae four, the proximal seta of both rows more than half as long as the remaining ones; lateral setae five or six; marginal setae of the median lobe four or five.

Thorax: femora without conspicuous rows of small setae; wing-cases extending caudad to the middle of the third abdominal segment.

Abdomen with distinct lateral keels all of which are setose including those of the first segment; the size of the setae gradually increases caudad, and on each lateral surface of the ninth segment there is a row of setae in line with the lateral keels with two or more setae grouped together at the caudal end of the row; gills (Fig. 71) clear and without cuticular pigmentation though reported by Lucas ('00: 103) to have one or more narrow cross-bands beyond the middle; dorsal and lateral gills with closely placed marginal setae which extend more than half-way from the bases to the apices of the gills; tracheal branches few in number and usually larger than are found in *civile* or *carunculatum;* ovipositor of the female extending caudad to the caudal margin of the tenth abdominal segment.

Measurements

Length	14 mm.
Length of abdomen	9 mm.
Length of gills	5 mm.
Width of gills	1.5 mm.
Length of metathoracic wing-cases	4 mm.
Length of median lobe	2.5 mm.
Width of median lobe	.75–2 mm.

Described from three nymphal exuvia from France (Martin), obtained from Mr. E. B. Williamson.

Adult; Male.—Color, pale blue and black.

Head black, blue, and buff; mouth-parts buff; median lobe subtriangular, the proximal segment of the labial palpi broad, the distal segment pale; antennae dark, the second segment much longer than the first; postclypeus black except the lateral margins and the ventral margin, the anteclypeus, labrum, mandibles, and the transverse stripe above the fronto-clypeal suture blue; genae, pale yellow; remainder of the front and vertex black; postocular spots large, blue, the margins of the spots irregular and the spots narrowly separated from the narrow stripe caudad of the ocellar area; occiput, except a stripe caudad of the postocular spots and the postgenae, pale blue.

Thorax: pronotum largely black, the cephalic lobe with the cephalic half blue, median lobes with large oval blue spots; proepimera and episterna blue with black dorsal borders; mesostigmal plates narrow and more than half pale; dorsal carina with the black stripe which covers it also covering one-half of each supraepisternum; black stripe of the mesopleural suture narrowed considerably caudad and covering about one-third of the mesinfraepisterna; remainder of the mesopleura, except a small spot on the mesopleural suture near the wing bases, pale blue; postcoxal areas yellowish blue; legs with blue coxae and trochanters, the trochanters dark on the dorsum; femora with a single black stripe on each dorsum, the stripe broken by a small spot at the base; cephalic half of the dorsum of the tibiae with black longitudinal stripes; tarsi pale yellow, darker at the distal ends; wings with twelve postnodal cross-veins in the front wing and ten in the hind; stigma surmounting less than a single cell, pale.

Abdomen blue and black; first tergum with small basal and smaller lateral black spots; second tergum blue with a subelliptical apical spot and an apical ring; terga three, four, and five with apical spots connected with the apical rings; apical half of the sixth and about four-fifths of the dorsum of the seventh with broad black stripes expanded caudad but not reaching the margins of the terga; terga eight and nine pale; dorsum of ten black, the caudal margin distinctly incised on the meson, the lateral surfaces of the segment pale yellow; first sternum pale, 3–8, inclusive, black; anal appendages (Figs. 201, 208) black and brown, the superiors short, bent ventrad and somewhat acute at the apex; inferiors much longer than the superiors and black at the tips.

Female.—Color in general similar to that of the male, the blue, however, replaced by yellow.

Head and thorax similar to those of the male except that they are somewhat lighter in color; mesostigmal plates as shown in Figure 213.

Abdomen with broad longitudinal stripes on the second tergum which are much expanded near the caudal margin; terga 3–7 with narrow longitudinal stripes, all of which are expanded near the caudal margin, the longitudinal stripe of eight much reduced near the cephalic margin (Fig. 93); anal appendages of the usual type; ovipositor short, the lateral valves pale, ventral margins slightly serrate; prostyles short and blunt.

Measurements

Length, ♂	31–32 mm.
Length, ♀	31–32 mm.
Length of abdomen, ♂	24 mm.
Length of abdomen, ♀	26 mm.
Length of hind wings, ♂	19–21 mm.
Length of hind wings, ♀	20 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4 mm.

This species is most closely related to *calverti*, from which the female differs in having more black on the dorsum of the eighth tergum and in the characters of the mesostigmal plates. The male may be distinguished by means of the anal appendages.

Described from a number of both sexes in the collection of Mr. E. B. Williamson. The species has not been reported from Illinois, but probably occurs here.

Enallagma divagans Selys

Nymph.—Unknown.

Adult; Male.—Color, blue and black.

Head blue and black; labium pale, median lobe subtriangular, the labial palpi including the distal segment pale, the proximal segment narrow; antennae dark, the first two segments subequal, the first pale at the tip; postclypeus black, anteclypeus except a small dorsomesal black spot, the mandibles, their trochantins, genae, and a transverse area above the fronto-clypeal suture pale blue; remainder of the front black; vertex with pale subcuneiform postocular spots, the remainder of the dorsal portion black; occiput and postgenae pale blue or buff with the exception of a large black spot laterad of the occipital foramen on each side.

Thorax blue and black; pronotum black, cephalic lobe largely blue, the median lobes with large spots adjacent to the proepimera, and the caudal lobe with small spots on the lateral angles and one on the meson; proepimera distinct blue and with a dorsal, crescentic, black spot; mesostigmal plates largely blue, the mesal angles black; mesosupraepisterna black, with blue longitudinal stripes from the cephalic margins to the wing bases, the stripe slightly widened cephalad, narrowed at the middle, and widened again caudad; mesopleural suture covered by a black stripe which occupies a portion of the supraepisterna and the epimera, being widest about the middle, narrowed near the wing bases, extending cephalad across the infraepisterna and covering about one half of those sclerites; remainder of the pleura blue, with the exception of spots on the interpleural fold and metapleural suture adjacent to the wing bases; legs buff or pale blue and black; coxae blue with a black basal spot on the cephalic surfaces; dorsum of the trochanters dark, remainder pale; femora with slight dorsal carina, the dorsal longitudinal stripes usually covering the carinae, but the stripes sometimes divided by a pale line on the carina, and emarginate at the proximal end; tibiae mostly pale with faint cephalo-dorsal stripes or row of dashes, the ventral surfaces with black spots at the base and apex; tarsi pale, the segments darker at the distal end; wings with twelve postnodal cross-veins in the front wing and ten in the hind wing; stigma pale, surmounting less than a single cell; M_2 arising near the fifth postnodal cross-vein in the front wing and between three and four in the hind wing.

Abdomen blue and black with a touch of bronze; first and second terga blue, with black, dorsal, longitudinal stripes, the first with a very narrow subapical ring of black which does not reach the lateral margins; longitudinal stripe of the second tergum expanded subapically and the tergum with a broader apical ring extending from the meson half-way to the lateral margins; terga 3–7 with dorsal longitudinal stripes which are contracted to the meson near the cephalic margin, but widen subapically and unite with the black apical rings; terga eight and nine entirely blue; dorsum of the tenth tergum entirely black, the venter pale blue or buff; anal appendages (Fig. 190) short, black, the superiors bilobed, the dorsal arm knob-like, the ventral lobe more slender; inferiors slender, directed obliquely dorsad and frequently in contact with the ventral arm of the superiors; first sternum pale, 3–9 black.

Female.—Color similar to that of the male.

Head similar to that of the male.

Thorax: black stripe of the mesopleural suture divided by a line of brown; mesostigmal plates as shown in Figure 224.

Abdomen: terga 1–7, inclusive, similar to corresponding terga of the male, the lateral blue stripes of the margin becoming dull brown on the apical segments; eighth tergum black, with pale blue lateral spots on the caudal margin; tergum nine blue, with two short dorso-lateral black stripes which fuse at the base of the meson; tergum ten blue; anal appendages dark brown, ovipositor pale buff, the prostyles short and blunt.

Measurements

Length, ♂	29–33 mm.
Length, ♀	32 mm.
Length of abdomen, ♂	24-28 mm.
Length of abdomen, ♀	26 mm.
Length of hind wings, ♂	17–18 mm.
Length of hind wings, ♀	18 mm.
Width of hind wings, ♂	3.5 mm.
Width of hind wings, ♀	3.5 mm.

This species is very closely related to *exsulans*, the male differing principally in the possession of blue on the eighth tergum and in the character of the anal appendages. The female can not be separated from *exsulans* except by the mesostigmal plates. It is, however, a much more slender and delicate insect.

Described from eighteen males and one female in the collection of Mr. E. B. Williamson.

A rare species, reported from Ohio, but not yet taken in Illinois by collectors.

ENALLAGMA DOUBLEDAYI Selys

Nymph.—Unknown.

Adult; Male.—Color, light blue and black.

Head blue and yellowish and black; antennae uniform brown, the second segment slightly longer than the first; anteclypeus and labrum shining yellow; exposed portions of the mandibles, their trochantins, genae, and the front dorsad of the clypeus to the level of the antennal fossae pale; remainder of the front black; postocular spots small, the narrow stripe caudad of the ocelli distinct; occiput and postgenae pale; compound eyes dark brown.

Thorax black, blue, and yellowish green; pronotum black, the cephalic lobe, a small spot on each median lobe, and the caudal margin of the caudal lobe pale; proepimera and episterna pale, the noto-epimeral suture indistinct; paraptera black; mesothorax with a broad black dorsal stripe, the stripe covering about one-third of the meso-supraepisterna on each side; remainder of the thorax, including the postcoxal areas, buff with the exception of small dark spots on the metapleural sutures near the wing bases; legs black and yellow, the coxae and trochanters pale, darker on the cephalic surfaces; femora each with a broad black dorsal stripe which frequently includes one row of setae; tibiae with longitudinal stripes on the cephalic surfaces; wings with about ten postnodal cross-veins in the front wing and eight in the hind one; M_2 arising between the fifth and sixth postnodal cross-veins in the front wing and between the fourth and fifth in the hind wing.

Abdomen blue and black; terga 1–10 blue except a small basal spot on the first, a hastate spot on the second, an apical spot and marginal ring on the second to the fifth, the apical half or two-fifths of the dorsum of the sixth, dorsum of the seventh (excepting a narrow interrupted basal ring), and the tenth, which are pale; anal appendages (Figs. 169,175) similar to those of *caruncidatum* and *civile*, but the superiors differ (compare Fig. 169 with Figs. 176 and 179) in having a smaller pale tubercle at the end and in being much wider proximad of the tubercle.

Female.—Color, similar to that of the male.

Head similar to that of the male.

Thorax: mesostigmal plates (Fig. 226) similar to those of *civile*, but the caudal margins concave, instead of convex as in the latter.

Abdomen: terga 1–10 with broad dorsal dark stripes and basal interrupted rings, the lateral margins pale; anal appendages of the usual type and the ovipositor pale, the ventral margins of the lateral valves serrate.

Measurements

Length, ♂	31 mm.
Length, ♀	31 mm.
Length of abdomen, ♂	25 mm.
Length of abdomen, ♀	24 mm.
Length of hind wings, ♂	17 mm.
Length of hind wings, ♀	18 mm.

Described from a number of specimens in the collection of E. B. Williamson.

This species has not been reported from Illinois. It has been collected in Ohio and was originally described from Florida. It is possible that it may occur occasionally in southern Illinois.

Enallagma ebrium (Hagen)

Nymph.—Not available for study.

Adult; Male.—Color, blue and black.

Head black and blue; mouth-parts pale, the labium with a subtriangular median lobe; labial palpi buff, the distal segment dark at the apex; antennae black except the tips of the first and second segments; postclypeus black; anteclypeus, labrum, exposed portions of the mandibles, their trochantins, genae, and a transverse stripe above the clypeus, pale; remainder of the front and vertex black; postocular spots large, subcuneiform, the margins irregular; occiput and postgenae pale except a transverse black stripe caudo-ventrad of the postocular spots.

Thorax blue and black; pronotum black, the cephalic lobe with a pale transverse stripe, median lobes with pale spots on the lateral and caudal margins of the caudal lobe; dorsal border of the proepimera black, the ventral two-thirds pale; mesostigmal plates elongate, the lateral angles covered with a pale spot and slightly elevated, though not as much as in *carunculatum* or *civile;* dorsal mesothoracic stripe occupying about one-third of each supraepisternum, the lateral margins parallel; pale stripe of the supraepisterna extending from the cephalic margin to near the paraptera, widest above the infraepisternum; black stripe of the mesopleural suture widest just caudad of the infraepisternum, and extending across and occupying about one-half of that sclerite; caudal margin of the metepisterna black and a black spot on the metapleural sutures cephalad of the wing bases; remainder of the pleura blue, the postcoxal areas buff; paraptera black, trapezoidal, the cephalic margins and a spot just below the lateral angles pale; legs striped, black and buff, the femora and coxae pale, the entire dorsum of the femora black except a small spot near the base, frequently appearing as an emargination of the black dorsal stripe; tibiae with a black stripe from base to near the apex, occupying half or less of the dorsal aspect and often including the cephalo-ventral row of setae; tarsi and claws pale, dark at the tips; wings with nine to ten postnodal cross-veins in the front wing; vein M_2 arising between the

fourth and fifth postnodal cross-veins in the front wing and between three and four in the hind wing.

Abdomen blue and black; terga largely blue, with black spots on the base of the first and the apices of 2–6 inclusive, all of the dorsum of seven blue except a basal interrupted ring, and all of ten blue; terga eight and nine blue; sterna 3–8 with mesal lines of black from the cephalic to near the caudal margins; anal appendages (Figs. 189, 196) short, pale, the superiors bifid, the two arms equal in length; dorsal arm of the superior appendages black at the tip and forming a blunt hook; ventral arm pale and nearly straight; inferior appendages pale, dark at the tips and about as long as the superiors.

Female.—Color, black and yellow or blue.

Head similar to that of the male, the blue, however, sometimes replaced by yellow.

Thorax similar to that of the male; mesostigmal plates as shown in Figure 227.

Abdomen with broad dorsal stripes on segments 2–10, the stripes contracted to the meson on the bases of terga 3–7 inclusive, and widened subapically on segments 2–7, the widened portion not reaching the lateral margins; first tergum pale, with a black spot at the base; sterna 1–8 with black median stripes; ovipositor of the usual form and not reaching caudad of the tenth segment, the ventral margins of the lateral valves feebly serrate.

Measurements

Length, ♂	29 mm.
Length, ♀	29 mm.
Length of abdomen, ♂	23–25 mm.
Length of abdomen, ♀	24 mm.
Length of hind wings, ♂	16–17 mm.
Length of hind wings, ♀	18 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4 mm.

The anal appendages of the male distinguish the species from closely allied members of the genus, and the mesostigmal plates of the females are also characteristic.

Described from a number of males from Illinois in the collection of the State Laboratory of Natural History, and from females in the collection of E. B. Williamson.

Enallagma exsulans (Hagen)

Nymph.—Color, dark brown or greenish.

Head slightly broader than long, the caudo-lateral angles projecting caudad and provided with heavy setae; second antennal segment shorter than the first, the first two darker than the remaining ones and pilose; labium extending just caudad of the procoxae, mental setae three in number; lateral setae four or five, and six or seven marginal setae on the median lobe.

Thorax: legs with a few hair-like setae, the femora each with a preapical ring of brown and the tibiae with the usual scales at the tip; apices of the third tarsal segments and the apices of the claws dark; metathoracic wing-cases extending caudad to the fourth abdominal segment.

Abdomen slender, the cuticle provided with minute setae and minute brown spots; lateral keels well developed on segments 1–8, the keels on segments 4–8 and the lateral apex of segment nine with small groups of two to five setae; gills (Figs. 53, 77, 77a) broadly lanceolate, broadest beyond the middle, usually heavily pigmented on the proximal two-thirds, the area of infuscation being followed by two large clear spots on each side of the axis, the distal end of the gill being dark, the extreme tip white; marginal setae of the median gill consisting of a dorsal row extending from the base to the light spots, or nearly two-thirds the length of the gills, and ventral marginal setae of the lateral gills of similar extent; apical margins of all gills hairy; smaller tracheae forming alga-like patches; ovipositor extending to the middle of the tenth abdominal segment.

Measurements

Length	12–13.5 mm.
Length of abdomen	9–10 mm.
Length of gills	5.5–7 mm.
Width of gills	1.8–2 mm.
Length of median lobe	2 mm.
Width of median lobe	.6–1.8 mm.

Adult; Male.—Color, pale blue, black, and brown.

Head pale blue and black; median lobe of the labium buff, subtriangular, the cleft obtuse at the base; antennae entirely black; postclypeus black, shining, the anteclypeus pale and the labrum with a transverse black stripe on the dorsal margin; exposed portions of the mandibles, their trochantins, genae, and a transverse area between

the compound eyes and above the clypeus, pale blue; remainder of the front, and the vertex, black; postocular spots and the postgenae and occiput yellow.

Thorax blue and black; pronotum largely black, the cephalic lobe blue; large spots on each mesal lobe and a smaller one on each, near the meson, blue, and a blue triangular mesal spot on the caudal lobe; proepimera largely blue, the dorsal sutures indistinct and covered with black; mesostigmal plates elongate, the lateral angles covered by a blue spot; dorsal carina with a broad, black stripe, which covers also about one-half of the mesosupraepisterna on each side; the dorsal stripe is followed on each supraepisternum by a narrower blue stripe extending from the cephalic margin caudad to near the paraptera, the stripe being narrowed at both ends; the black stripe of the mesopleural suture is broad, extends ventrad well onto the metepimera, and in younger specimens is divided by a brown line which is directly over the suture; dorsal third of the mesinfraepisterna, and spots on the metapleural sutures near the wing bases, dark brown or black; remainder of the pleura blue, postcoxal areas brownish or buff; legs pale blue, or brown and black, the coxae and trochanters pale, the femora each with a faint dorsal carina on one side of which is an indefinite line and on the other a row of spots, the hind femora, however, often entirely pale; tarsi and claws pale, dark at the tips; wings with ten to eleven postnodal cross-veins and M_2 arising between the fourth and fifth postnodal cross-veins in the front wings and between three and four in the hind wing.

Abdomen blue and black, the dorsum of terga 1–9 and ten with longitudinal black stripes from base to apex, widened subapically on segments 2–7 and narrowed to the meson on the apex of the eighth tergum; lateral surfaces of terga 1–8 and ten, all of nine, narrow apical ring on one, narrow basal ring on three, and a broad basal ring on four, five, and six, blue or pale; anal appendages (Figs. 203, 210) black, the superiors bifurcate, the dorsal arms shortest and with minute points directed mesad; inferiors paler and shorter than the superiors.

Female.—Color, pale green (pale viridine green), black, and brown, tip of the abdomen blue.

Head similar to that of the male except that the postocular spots are connected with the narrow stripe caudad of the ocelli, and the genae and stripe above the clypeus are usually more or less orange in color.

Thorax with the brown of the mesopleural dark stripe covering the suture more conspicuous and persistent than it is in the male; mesostigmal plates as shown in Figure 220.

Abdomen with broad dorsal stripes on segments 1–8, the stripe on nine being reduced to two triangular spots at the base of the tergum, the remainder being blue in color; tergum ten blue; lateral surfaces of terga 2–8 and narrow interrupted basal rings on segments 3–8 pale green; sterna 2–8 with black mesal lines, the eighth with a long apical seta; ovipositor and anal appendages of the usual form, the lateral valves of the ovipositor blue or pale and serrate on the ventral margins; prostyles dark brown.

Measurements

Length, ♂	35 mm.
Length, ♀	32 mm.
Length of abdomen, ♂	29 mm.
Length of abdomen, ♀	26 mm.
Length of hind wings, ♂	19 mm.
Length of hind wings, ♀	20 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	5 mm.

One of the most common and wide-spread species of the state. The nymphs prefer meadow brooks, but also inhabit small lakes and ponds. In numbers this species is equal to *signatum*. The adults emerge early and fly throughout the summer.

Specimens have been seen from Dubois, Carbondale, Carmi, Golconda, Lake Villa, Oregon, and Cook County.

Enallagma geminatum Kellicott

Nymph.—Color, usually green.

Head about three times as broad as long, elliptical, the caudolateral angles not projecting caudad or laterad, evenly rounded, and possessing only a few setae; third segment of the antennae longest and the second segment decidedly longer than the first; segments 1–3 or 1–4, dark in color; labium extending slightly caudad of the procoxae; median lobe with three mental setae and sometimes a minute fourth; lateral setae five; median process of the labial palpi with only two teeth; lateral margins of the median lobe with three or four small setae caudad of the articulations of the labial palpi.

Thorax: legs without dark rings near the apex or with very faint ones, the femora provided with rather long setae; tarsal claws dark at

the tips; metathoracic wing-cases extending to the caudal margin of the fourth abdominal segment.

Abdomen with moderately well-developed lateral keels on segments one to eight inclusive, the first without setae, the second with a bunch of three or four, the third with an irregular double row, and the fourth to the eighth possessing irregular single rows, with sometimes two setae at the apices; segment nine, although possessing no keel, has an irregular double row of setae in line with the keels of the preceding segments; gills spatulate to lanceolate (Fig. 72), without pigment except in the smaller tracheae and sometimes a trace along the axis; dorsal marginal row of setae of the median gill extending much less than half the length of the gill and containing seventeen or eighteen setae, the ventral row of the same gill short and composed of only a few setae; ventral marginal row of the lateral gills also less than one-half the length of the gills; the black tracheae of the gills differ greatly from those of other clear-gilled species in being fewer in number and branching from the axis more nearly at right angles; ovipositor extending caudad to the apex of the tenth abdominal segment.

Measurements

Length	11–12 mm.
Length of abdomen	9 mm.
Length of gills	4.7 mm.
Width of gills	1.3 mm.
Length of metathoracic wing-cases	2 mm.
Length of median lobe	2 mm.
Width of median lobe	.6–1.5 mm.

Adult; Male.—Color, pale blue (pale methyl-blue), black, and buff.

Head blue and black, the mouth-parts buff, with a tinge of blue; median lobe of the labium subtriangular, the cleft shallow and rounded at the proximal end; labial palpi with slender distal segments, pale, and not darker at the tip; antennae dark brown or black, the tips of the first and second segments sometimes pale; postclypeus shining black except the latero-ventral angles, which are blue; anteclypeus and labrum except a small dorso-mesal black spot, blue; exposed portions of the mandibles, their trochantins, genae, and a transverse area dorsad of the clypeus blue; remainder of the front black; postocular spots large, blue, rather irregular and frequently serrate on the margins; pale stripe caudad of the ocelli wanting; occiput and postgenae buff,

except a transverse stripe caudad of each postocular spot; compound eyes dark brown above, the brown area including a crescent-shaped paler stripe, the eyes pale yellow below.

Thorax blue and black, buff below; pronotum black, the narrow cephalic lobe and the caudal lobe largely blue, the median lobes entirely black; proepimera largely blue; mesostigmal plates narrow, the lateral angles and the caudal margin with a broad blue stripe; black stripe of the dorsal carina covering one-third to one-half of each mesosupra-episternum; supraepisternal blue stripe somewhat irregular, not reaching the caudal margin of the sclerite, contracted at the caudal third or fourth, and occasionally interrupted, forming an exclamation point; mesopleural black stripe of the suture widest adjacent to the infra-episternum and covering the dorsal third of that sclerite; at the caudal extremity the stripe extends ventrad along the caudal margin of the mesepimera to the interpleural fold; metapleural suture with a black line; remainder of the pleura, including the ventral half of the mes-epimera, all of the metepisterna, and the epimera, blue; postcoxal areas pale or buff; legs striped, black and blue or buff, the coxae and the trochanters mostly pale, the coxae sometimes with dark spots; femora each with a broad dorsal stripe from base to the apex and the tibiae with a brown or black stripe occupying half the dorsum and frequently including the cephalo-ventral row of setae; tarsi and claws black, the claws deeply bifid at the tip; wings with seven to nine post-nodal cross-veins and with M_2 arising between the fourth and fifth postnodal veins in the front wing and between three and four in the hind wing.

Abdomen blue, buff, and black; first tergum blue, a black basal spot occupying half the dorsum, and the caudo-lateral margin black; second tergum blue except a subapical dorsal spot, an apical ring, and a longitudinal stripe near the lateral margin, which are black; segments 3–7 with longitudinal black stripes on the dorsum from near the bases to the apices, the stripes widened subapically, connecting with the apical rings and extending to the lateral margin of the terga; entire dorsum of tergum ten and a narrow lateral marginal stripe from bases to apices of terga eight and nine black or dark brown, the whole of the dorsum of the eighth and ninth terga pale blue; lateral margins and basal rings of terga 3–6 pale yellow or blue, the lighter color connecting across the dorsum on the bases of the third and fourth terga and extending onto the dorsum but interrupted on the meson in terga 5–7; anal appendages (Figs. 204, 211) black and buff, the superiors black, with paler tips, and curved ventrad and caudad;

inferiors slightly longer than the superiors, yellowish buff with black tips, the tips directed mesad.

Female.—Color, similar to that of the male.

Head similar to that of the male except that the dorsal half or third of the labrum is usually brown.

Thorax similar in all respects to that of the male; mesostigmal plates as shown in Figure 216.

Abdomen with broader dorsal stripes on terga 2–7, all of which extend to the bases of the segments; terga nine and ten entirely brown except the pale lateral margins; tergum seven brown, with large blue spots occupying the larger portion of the sclerite and separated from one another only by a mesal line of black; dorso-apical margin of seven and eight blue; sterna 2–8 with a black mesal line, the eighth with a long apical seta; anal appendages of the usual type, the lateral valves of the ovipositor broad and serrate on the ventral margins; prostyles dark brown, short.

Measurements

Length, ♂	26–27 mm.
Length, ♀	26–27 mm.
Length of abdomen, ♂	21 mm.
Length of abdomen, ♀	21 mm.
Length of hind wings, ♂	15 mm.
Length of hind wings, ♀	16 mm.
Width of hind wings, ♂	3.5 mm.
Width of hind wings, ♀	4 mm.

This species is characteristic of the smaller lakes and larger ponds, the nymphs inhabiting floating vegetation, and the adults flying near the surface of the water close to the habitat of the nymphs. The nymphs do not live in meadow brooks or swift streams.

Both nymphs and adults were taken at Havana, Illinois, and at Lake Villa during the latter part of June and the first of July.

Enallagma hageni (Walsh)

Nymph.—Color, buff or greenish.

Head subelliptical, the caudo-lateral angles projecting slightly caudad and armed with a few heavy setae; antennae with the third segment longest, the second longer than the first; labium, when folded, extending caudad to the second pair of coxae, the mental setae of the median lobe three, the lateral setae usually five, and the marginal setae of the median lobe usually three or four.

Thorax nearly uniform in diameter throughout, the prothorax somewhat smaller; legs with faint preapical femoral rings of brown, and the usual apical scales present on the tibiae; tarsi and claws pale; metathoracic wing-cases extending to the middle of the fourth abdominal segment.

Abdomen slender, and with a row of spots on the cephalo-lateral angles of the terga and sterna of segments 2–9; lateral keels strongly developed, setose, the first keel usually without setae, the second, third, and fourth with a bunch of four or five at the apices, the fifth with about five apical setae and a weaker row extending to the base of the segment; sixth, seventh, and eighth keels with six setae at the apices and a proximal row of about nine setae on each; segment nine without lateral keel, but with a row of setae along the line of the lateral keels, composed of two heavy setae near the caudal margin and a straight row of six smaller setae extending cephalad to the margin of the segment; cuticle of the abdomen without dark spots at the bases of the minute setae which cover the surface; dorsum of segments two and three and the base of four with long hairs; gills (Fig. 76) lanceolate, almost colorless, widest beyond the middle and rather obtusely pointed; tracheae pigmented in certain areas which form about twelve alga-like patches around the margins of the gills; dorsal marginal setae of the median gill extending half-way from the base to the tip and composed of more than twenty setae; ventral setae of the lateral gills extending more than half-way from the base to the tips of the gills; apical margins of all gills with a few scattered hairs.

Measurements

Length	14–15 mm.
Length of abdomen	9 mm.
Length of gills	5 mm.
Width of gills	1.8 mm.
Length of metathoracic wing-cases	3.6 mm.
Length of median lobe	2 mm.
Width of median lobe	.7–1 mm.

Several specimens obtained from Dr. E. M. Walker have been studied. Specimens of this species are also present in the collection of the Illinois State Laboratory of Natural History and have been identified by comparison.

Adult; Male.—Color, pale blue and black.

Head black and yellowish, the mouth-parts buff, the median lobe of the labium subtriangular; antennae black or very dark brown;

postclypeus largely black, the anteclypeus and the labrum shining yellow; exposed portions of the mandibles, their trochantins, genae, and a transverse stripe dorsad of the clypeus yellow; remainder of the front black; the oval postocular spots and the narrow transverse stripe caudad of the ocelli green; occiput and postgenae pale; compound eyes dark brown.

Thorax black, blue, and yellowish green; pronotum dull black, the cephalic lobe, a small spot near the lateral margin of each median lobe, and the caudal margin of the caudal lobe yellowish green; pro-epimera pale, the noto-epimeral sutures indistinct; mesostigmal plates with a pale lateral spot; paraptera black; mesothorax with the usual dorsal stripe, a broad pale stripe on each supraepisternum, and a black stripe covering the mesopleural suture, extending over the infraepisternum, and covering about one-third of that sclerite; remainder of the thorax, including the postcoxal areas, yellowish green or blue with the exception of a small dark spot on the metapleural suture just cephalad of the wing bases; legs black and yellow, the coxae and trochanters pale, the femora each with a broad black dorsal stripe from base to apex, and the tibiae with a similar stripe on the cephalic surfaces, which frequently includes one of the rows of setae; tarsi and claws brown, black at the apices; wings with ten postnodal cross-veins in the front wing and about eight in the hind one; M_2 arising between the fourth and fifth postnodal cross-veins in the front wing and between the third and fourth in the hind wing.

Abdomen blue and black; terga 1–10 blue except a small black basal spot on the first, an apical spot and marginal ring on the second to the fifth, the apical half or two fifths of the dorsum of the sixth, the dorsum of the seventh except a narrow interrupted basal ring, and the dorsum of the tenth, which are black; anal appendages (Figs. 161,162) short, the inferiors subconical, the superiors slightly shorter, broad and flat, subquadrangular when seen from above, pointed, and similar in appearance to the inferiors when seen in lateral profile.

Female.—Color, yellowish green and black.

Head similar to that of the male.

Thorax also like that of the male; the mesostigmal plates (Fig. 221) are characteristic, being short and broad and having the caudolateral angles distinctly elevated; the blue of the male thorax is usually replaced by a yellowish green.

Abdomen black and yellow; terga 1–10 black except the lateral surfaces and an apical ring on the first, lateral surfaces of 2–10, and interrupted basal rings on 3–6 inclusive, which are pale blue or green-

ish; anal appendages of the usual type; the lateral valves of the ovipositor are pale yellow, the prostyles light brown; apex of the eighth sternum with a long seta.

Measurements

Length, ♂	30 mm.
Length, ♀	30 mm.
Length of abdomen, ♂	23–24 mm.
Length of abdomen, ♀	23–24 mm.
Length of hind wings, ♂	17 mm.
Length of hind wings, ♀	17 mm.
Width of hind wings, ♂	3.5 mm.
Width of hind wings, ♀	4 mm.

A common species in the lake region of Illinois, but not observed as far south as Urbana. The adult female is closely related to *carunculatum* and *civile*, from which it may be separated by means of the wing venation, the vein M_2 usually arising between the third and fourth postnodal cross-veins, by the narrower pale abdominal rings at the bases of the terga, and by the character of the mesostigmal plates. The males are easily separated from *carunculatum* and *civile* by means of the anal appendages.

Enallagma pollutum (Hagen)

Nymph.—Color, pale green or buff.

Head elliptical, about twice as broad as long, the caudo-lateral angles slightly projecting and furnished with but few setae; antennae of the usual form as regards length of the segments, the first two segments, however, being much thicker than the distal ones and the second usually shorter than the first; first antennal segment dark in color, the remaining ones paler; labium extending slightly caudad of the first pair of coxae, with three mental setae; five lateral setae and three or four marginal setae on the median lobe.

Thorax about twice as long as broad; legs light in color, with a few scattered setae, the femora with preapical rings of brown, the tibiae sometimes with a dorsal row of black dashes; metathoracic wing-cases reaching the middle of the third abdominal segment.

Abdomen slender, the lateral keels strongly developed and setose, the setae being grouped conspicuously near the apices of the keels, especially on segments 2–6; dorsa of segments 4–10 with apical transverse rows of small setae, the row on the tenth interrupted on the line of the meson, and those on 2–5 irregular, and consisting of several

rows together; ovipositor extending to the middle of the tenth abdominal segment, the ventral margins of the lateral valves with a single row of setae; venter of the abdomen without the median black stripe of *signatum*, but with a double row of black spots near the apical margins, two on each of segments one to six and sometimes on seven also; gills (Fig. 57) lanceolate, frequently much and suddenly widened beyond the middle, conspicuously banded, usually with two darker cross-bands (more or less fused) near the proximal third and three lighter crescentic ones which are sometimes wanting, axis dark, the median gill without dorsal marginal setae, the ventral margins of the lateral gills with a thick row extending slightly more than one-third the length of the gills from their bases, or extending from the base to the point where the first dark cross-band reaches the margin.

Measurements

Length	15.5 mm.
Length of abdomen	9 mm.
Length of gills	5.5 mm.
Length of metathoracic wing-cases	4.1 mm.
Length of median lobe	1.8 mm.
Width of median lobe	.5–1.5 mm.

Adult; Male.—Color, lemon-yellow (strontian yellow) or very pale blue, and black; the majority of specimens are yellow, the blue tenerals being infrequent.

Head yellow and black; labium pale yellow, median lobe subtriangular; antennae brown and pale, the first segment and basal two-thirds of the second pale, the remainder dark brown; postclypeus with a large black spot occupying almost the whole of it and within which are two small yellow spots; anteclypeus and labrum yellow except a median, dorsal, brown spot on the labrum; exposed portions of the mandibles, trochantins, genae, and a transverse area above the clypeus extending dorsad to the level of the median ocellus, yellow; remainder of the front black except a small transverse stripe cephalad of the median ocellus and small spots cephalo-ventrad of the lateral ocelli; postocular spots large, cuneiform, connected with the narrow stripe caudad of the ocellar area; the black of the vertex extends along the margin of the compound eyes a short distance caudad and ventrad of the postocular spots and sends mesad a broad, short band; remainder of the occiput and postgenae pale yellow.

Thorax yellow and black; pronotum yellow and black, the broad cephalic lobe mostly yellow, the median lobes each with a large yellow

spot and a smaller one mesad of it; caudal lobe with a yellow caudal margin; proepimera yellow, with very little black or brown; mesostigmal plates subtriangular, yellow, with a small brown spot near the mesal margin, the caudo-mesal angles slightly elevated, dorsal carina covered by a broad black stripe, the lateral margins of which fade into brown; black stripe of the mesopleural suture reduced to an indefinite pale brownish area near the middle of the horizontal portion of the suture; black spots adjacent to the dorsal margin of the mesinfraepisterna and small spots just cephalad of the wing bases; dorsal third of the mesinfraepisterna marked with small, crescentic, black spots; metapleural sutures with small black spots just cephalad of the wing bases; remainder of the mesopleura yellow; paraptera black with yellow cephalic margins and pale spots ventrad of the lateral angles; legs mostly yellow, the coxae and trochanters pale, the femora with a faint dorsal line, the tibiae with a faint indefinite dorsal line or row of dashes, and the tarsi and claws tipped with brown; wings with nine to eleven postnodal cross-veins and with M_2 arising between the fourth and fifth postnodal veins in the front wing and between three and four in the hind wing.

Abdomen yellow and black, the dorsum of terga 1–8, inclusive, with black longitudinal stripes from near the base to the apex of each; lateral stripes on terga 1–7, narrow basal rings on 3–7, and a very narrow apical ring on the first tergum, yellow; all of the ninth and tenth terga blue except a narrow mesal line on the tenth; sterna 3–8 with a mesal line of black; anal appendages (Figs. 186, 193) brown, the superiors much longer than the inferiors, broad at the apices, and with the caudo-dorsal and caudo-ventral angles folded mesad; inferiors small and yellow, the black apices directed mesad.

Female.—Color, lemon-yellow or very pale blue, and black.

Head similar to that of the male.

Thorax of slightly paler tint than in the male; mesostigmal plates (Fig. 225) with a large lateral black spot, the lateral margins rounded, and the plates contiguous with the mesinfraepisterna.

Abdomen yellow and black, the terga similar to those of the male with the exception of nine and ten, which are usually yellow, the ninth having a triangular black spot at the base; sterna 2–8 with a mesal line of black, the eighth with a long seta at the apex; lateral valves of ovipositor yellowish, serrate on the ventral margins, the prostyles brown.

Measurements

Length, ♂ ....34 mm.
Length, ♀ ....34 mm.

Length of abdomen, ♂ ....28 mm.
Length of abdomen, ♀ ....27 mm.
Length of hind wings, ♂ ....19 mm.
Length of hind wings, ♀ ....21 mm.
Width of hind wings, ♂ ....4 mm.
Width of hind wings, ♀ ....3.5 mm.

A species of apparently local distribution, occurring in the lake region of Illinois. Several collections of nymphs and adults were made at Lake Villa, July 13 and 14, 1915, and a number of adults were reared from the nymphs.

While closely related to *signatum*, the nymph shows a great difference in the gills, making it recognizable at sight. It is quite different from the species figured by Walker as *pollutum* ('13; pl. 1, fig. 10), and his description also differs from the specimens obtained at Lake Villa.

Enallagma signatum (Hagen)

Nymph.—Color, buff or greenish.

Head elliptical in outline, the caudo-lateral angles not projecting strongly, but thickly studded with short setae; first two segments of the antennae dark in color, nearly equal in length, the second slightly shorter, the third longest, and the remaining ones decreasing successively in length; labium, when folded, extending just caudad of the procoxae, with three mental setae, five lateral, and three or four smaller ones on the margin of the median lobe.

Thorax: legs light in color except a dark ring on the apical third of each femur and the tips of the third tarsal segments; femora with a few small setae and scattered hairs; metathoracic wing-cases extending nearly to the fourth abdominal segment.

Abdomen: the segments of the abdomen appear to have a greater transverse diameter near the apical fourth on account of the projecting lateral keels; the keels are well developed and setose, the setae being grouped mainly at one point near the apex of the keel; dorsum of segments 4–8 with short apical rows of small, heavy setae, terga nine and ten with longer rows, usually extending onto the venter; sterna two, three, and four with a cluster of small thick setae on the apical third, and the venter with a black line extending from the basal segment to segment nine; gills (Figs. 56, 69) lanceolate, the dorsal marginal setae of the median gill grouped mainly at one point, usually just proximad of the point where the first transverse band reaches the margin; beyond the ventral marginal row of setae the margins of the lateral gills are distinctly emarginate; the pigmentation of the

gills consists of three to five broad, black cross-bands and a broad axial band from the bases to the apices; ovipositor extending to the middle of the tenth abdominal segment.

Measurements

Length	16–18 mm.
Length of abdomen	10.5–12.5 mm.
Length of gills	5.5 mm.
Width of gills	1.6 mm.
Length of metathoracic wing-cases	4 mm.
Length of median lobe	2 mm.
Width of median lobe	.5–1.8 mm.

Adult; Male.—Color, pale blue or orange, and black.

Head blue or orange, and black; mouth-parts buff, the median lobe of the labium subtriangular, the palpi pale; first two segments of the antennae pale, at least much paler than the distal ones, the second segment darker at the tip; postclypeus black, sometimes with a pair of median pale spots, one on each side of the meson; anteclypeus pale; labrum pale, the dorsal margin with a mesal black spot and two lateral ones, or with a transverse stripe of black including the three spots; exposed portions of the mandibles, their trochantins, genae, and a transverse stripe above the clypeus extending slightly dorsad of the antennae, orange or blue; remainder of the front and vertex black; postocular spots large, cuneiform, and yellow or blue; postgenae and the occiput largely yellow.

Thorax orange or blue, and black; pronotum black, the cephalic lobe, a subcircular spot on each median lobe, and the entire caudal lobe blue or yellow; the spots on the median lobes are variable, being frequently subcircular with an emargination on one side; in younger individuals there are also two smaller spots mesad of the large spots on each mesal lobe; proepimera blue or yellow, the dorsal margins covered by a black stripe; stigmal plates triangular, the caudo-mesal angles elevated, and the caudal margins with a blue or yellow stripe; dorsal carina covered by a black stripe, the margins of which are parallel and very straight; mesopleural suture also with a broad stripe which is widest just caudad of the mesinfraepisternum and extends cephalad and covers the dorsal third of that sclerite; remainder of the thorax pale blue or orange, buff-colored below; paraptera trapezoidal, black, the cephalic margins and a spot below the lateral angles pale; legs usually buff, the femora with an indefinite dorsal brown line and a row of spots, the tibiae with a faint dorsal line or row of dashes;

tarsi pale, darker at the apices; wings with ten postnodal cross-veins in the front wing and eight in the hind one; M_2 arising near the fifth postnodal vein in the front wing and between the fourth and fifth or between the third and fourth, usually near the fourth, in the hind wing.

Abdomen orange or blue and black; dorsum of terga 1–8 inclusive, black, except interrupted basal rings on 3–7, lateral surfaces of one and two, and the lateral margins of 3–8; all of tergum nine and the lateral surfaces of the tenth orange or blue, the dorsum of ten being black; anal appendages (Figs. 185, 192) dark brown, the superiors much longer than the inferiors, blunt at the apices, the lateral surfaces convex, the mesal surfaces somewhat concave; inferiors about half as long as the superiors and subconical, the tips black and directed mesad.

Female.—Color, pale blue or orange, and black.

Head similar to that of the male.

Thorax similar in all particulars to that of the male; the orange-colored females are, however, less frequent; mesostigmal plates (Fig. 214) long, the lateral margins rounded, and a diagonal pale stripe crossing the plates.

Abdomen blue or orange, and black; terga 1–9 with black, dorsal, longitudinal stripes from the bases to the apices, the stripes widened near the apex on 2–7 and narrowed on the apex of nine; lateral surfaces of all terga, basal rings on 3–7, and an apical ring on one, yellow or bluish; all of segment ten yellow or blue; sterna 3–8 black; anal appendages of the usual form; ovipositor with the lateral valves pale and serrated on the ventral margins, the prostyles brown.

Measurements

Length, ♂	34–35 mm.
Length, ♀	34–35 mm.
Length of abdomen, ♂	26–28 mm.
Length of abdomen, ♀	28 mm.
Length of hind wings, ♂	17 mm.
Length of hind wings, ♀	20 mm.
Width of hind wings, ♂	3.5 mm.
Width of hind wings, ♀	4 mm.

One of the commonest species in Illinois, occurring in all localities. Next to *Ischnura verticalis* it may be considered as the most abundant.

The nymphs may be collected in slow streams, permanent ponds, or lakes, and prefer the clear water. They emerge in central Illinois

as early as the tenth of May and the greatest number of adults appear on the wing about June 1. The latest emergence which is recorded is one on June 25, 1915. This gives a period of emergence of at least a month and a half.

Specimens have been seen from Havana, Lake Villa, Muncie, Peoria, and Urbana.

Enallagma traviatum Selys

Nymph.—Color, very dark brown.

Head about one-third as long as broad, dark in color; caudo-lateral margins projecting caudad, studded with short setae; antennae very slender, the first two segments with setae and of much greater diameter than the remaining ones, the third segment longest, the second decidedly shorter than the first; labium extending slightly caudad of the first pair of coxae; mental setae two, with sometimes a rudimentary third, lateral setae four; marginal setae of the median lobe six or seven.

Thorax: lateral portions of the prothorax and the metapleura darker than the dorsum of the thorax; legs slender, the coxae dark brown, femora almost wholly devoid of setae, but with very distinct preapical brown rings; tibiae with setae which are rather closely set, especially towards the apices; tarsi pale.

Abdomen brown, darker immediately above and below the lateral keels; cuticle with a few minute setae, but lacking minute black spots entirely; lateral keels feebly developed and without heavy setae, there being instead a few setae near the apices of the keels; gills (Fig. 55) rather narrowly lanceolate, the median gill entirely without heavy setae on the dorsal margin; lateral gills with the ventral marginal row of setae extending one-half or less of the length of the gills; basal two-fifths or one-half of the gills uniform dark brown, the pigmented area followed by a broad white or clear band extending from margin to margin and including the axes; beyond the clear portions there are frequently one or two brown transverse stripes, the apex of the gills being without pigment; ovipositor extending caudad to the apex of the tenth sternum, the ventral margins of the lateral valves with one or two heavy setae and a number of hairs.

Measurements

Length	11 mm.
Length of abdomen	8 mm.
Length of gills	6 mm.
Width of gills	1 mm.

Length of metathoracic wing-cases . . . 3.5 mm.
Length of median lobe . . . . 2 mm.
Width of median lobe . . . . .5–1.3 mm.

Adult; Male.—Color, pale blue and black.

Head blue and black; labium buff, the median lobe with a broad median cleft; distal segment of the labial palpi pale; antennae brown, the first segment sometimes with the cephalic half blue; postclypeus blue with a small black spot on each side; anteclypeus blue; labrum blue with a black dorso-mesal spot; exposed portion of the mandibles, their trochantins, genae, and the front from the fronto-clypeal suture dorsad to the median ocellus, blue; lateral ocelli with small blue spots ventrad of them, and a similar spot between the ocelli; remainder of the front black; postocular spots very large, forming equilateral triangles and occupying most of the dorsal portion of the occiput, the spots bounded caudad by a very narrow black band and separated from the compound eyes by a band of similar width; the narrow stripe caudad of the ocellar area is indistinct; occiput and postgenae pale blue.

Thorax blue and black; pronotum blue and black, the cephalic lobe with a transverse line of blue on the caudal margin, the median lobes with elongate blue spots, contiguous on the meson, and semicrescentic spots of the same color; proepimera and proepisterna brown or pale; mesothorax with the narrow black stripe covering the dorsal carina but frequently divided there by a line of brown; black stripe of the mesopleural suture reduced to a line on the suture; mesinfraepisterna with black crescentic marks on the dorsal borders; remainder of the pleura blue with the exception of small spots on the interpleural folds and metapleural sutures adjacent to the wing bases; postcoxal areas pale; paraptera black, crescentic, the cephalic margins and lateral angles blue; legs striped, pale blue or buff and black, the coxae and trochanters blue, the femora blue with broad dorsal black stripes which are frequently interrupted at the base by a pale spot; tibiae pale blue and buff with a short dorsal black stripe or none, the tarsi pale, black at the tips; claws deeply bifid and black at the tips; wings with ten postnodal cross-veins in the front wing and eight in the hind one; M_2 arising between the fourth and fifth postnodal cross-veins in the front wing and between three and four in the hind one; stigma small, subelliptical, and surmounting less than a single cell.

Abdomen blue and metallic black, the dorsum of the first tergum with a small black basal spot about half the length of the tergum; second tergum with a black, apical, shield-shaped spot, the spot extending to the cephalic margin and narrowed at this point to a line on the me-

son; terga 3–7, inclusive, with longitudinal black stripes widened subapically and narrowed basally, the lateral margins of the terga pale; terga eight and nine usually entirely blue, the eighth sometimes with a basal spot on the dorsum; tenth tergum black; anal appendages (Figs. 199, 206) short and black, the superiors slightly longer than the inferiors and appearing slightly knobbed at the apices when seen in lateral profile; viewed from above, the superior appendages are seen to have broad basal lobes which are often contiguous on the meson; inferior appendages short, subconical, and directed obliquely dorsad; first sternum pale, 3–8 black, the tenth pale.

Female.—Color similar to that of the male.

Head similar to that of the male except that the front is paler and the spots ventrad of the lateral ocelli are larger and connect with the pale color of the ventral portions of the front; the black borders of the postocular spots are narrower than those of the male.

Thorax: dorsal stripe divided by a line of brown on the carina; mesostigmal plates pale blue, the lateral angles elevated (Fig. 214), and a sinuate dark stripe on the supraepisterna just caudad of the plates; mesopleural suture with a distinct spot cephalad of the wing bases and the black of the infraepisterna reduced to narrow dorsal lines; postnodal cross-veins of the front wing ten to eleven, of the hind wing nine to ten.

Abdomen: dorsum of the first tergum with a black basal spot, 2–7, inclusive, with narrow dorsal longitudinal stripes, widened suddenly near the caudal margins and narrowed to the meson near the cephalic margins; tergum eight blue with a narrow dorsal stripe extending a little over half the length of the tergum from the base, (Fig. 94); ninth and tenth terga blue; anal appendages of the usual form; ovipositor with broad, blue, lateral valves; first and second sterna pale, with black mesal lines, 3–8, inclusive, black.

Measurements

Length, ♂	31 mm.
Length, ♀	31 mm.
Length of abdomen, ♂	25 mm.
Length of abdomen, ♀	25 mm.
Length of hind wings, ♂	17 mm.
Length of hind wings, ♀	18.5 mm.
Width of hind wings, ♂	3.25 mm.
Width of hind wings, ♀	3.5 mm.

This species was collected at Carbondale, Ill., June, 1915, and was reared at that time. It has not been reported elsewhere in the state but doubtless occurs about glacial lakes and ponds.

The nymph differs from that of *exsulans* chiefly in the darker color. In all the specimens studied the labium has only two mental setae as compared with three in *exsulans*. The gills show considerable difference in the shape and pigmentation, particularly of the apical portions.

The adult is most closely related to *exsulans*, but both sexes may be distinguished by the reduced amount of black on the mesopleural suture, the greater amount of blue on the front, and the exceedingly large postocular spots.

Genus Nehalennia Selys

The nymph of the only representative of this genus occurring in Illinois is characterized by its peculiar type of gills, in which the tracheae are much more numerous near the widest portion of the gill than elsewhere.

The dominant color of the adult is metallic green or bronze, the mesepisterna being entirely without pale stripes and the pronotum without pale spots. The female has the caudal lobe of the pronotum trilobed and the eighth sternum is without the ventral apical seta. The sternites at the base of the cephalic pair of gonapophyses are minute and scarcely visible.

Nehalennia irene Hagen

Nymph.—Color, brown or green.

Head oval in outline, the caudo-lateral angles with but few setae; antennae with the second segment longer than the first, the second segment and proximal third of three dark in color; labium, when folded, extending nearly to the mesocoxae, with a single large mental seta and a smaller one alongside; lateral setae five, and the lateral margins of the median lobe with about five small setae.

Thorax: femora and tibiae with rows of sparsely placed setae, the preapical rings of brown on the femora very indistinct; apical tibial scales present; wing-cases extending nearly to the apex of the fourth abdominal segment.

Abdomen slender, with feeble lateral keels, the cephalic two or three without setae, the caudal ones with not more than six or seven; cuticle of the abdomen with small whitish spots on a darker background; gills (Fig. 61) much broader beyond the middle, the lateral

gills with ten to twelve black cuticular spots on the margins and a distinct arcuate cross-band just beyond the middle; tracheal branches much more numerous beyond the middle of the gill; marginal setae large and widely separated, the ventral row of the lateral gills extending about half the length of the gill from the base and the distal setae much farther apart than the proximal; ovipositor usually extending beyond the apex of the tenth segment.

Measurements

Length	10–11 mm.
Length of abdomen	8 mm.
Length of gills	4–4.5 mm.
Width of gills	1 mm.
Length of median lobe	1.5–1.7 mm.
Width of median lobe	1.25 mm.

Described from three specimens obtained from Dr. E. M. Walker, and labeled Toronto, Ont., May 31, 1913.

Adult; Male.—Color, metallic green and pale blue.

Head metallic green above, buff below; median lobe buff, the cleft large and rounded at the base; distal segments of the labial palpi dark at the tips; antennae black, the second segment with a pale ring at the middle; postclypeus shining black, the anteclypeus buff; labrum pale yellow with a dorsal, transverse, shining black stripe about one-third the width of the piece; exposed portions of the mandibles, the trochantins, genae, and the front from the fronto-clypeal suture dorsad to the antennal fossae, shining yellow; remainder of the front, vertex, and a large portion of the occiput, metallic green; postgenae black, with a pale stripe beneath the compound eyes which is continuous with the yellow of the genae; compound eyes brown.

Thorax metallic green and pale blue; pronotum metallic green without paler spots, the margin of the caudal lobe entire; proepimera buff-colored; dorsal carina and the mesopleural suture lined with black; mesosupraepisterna and the mesepimera except the cephalo-ventral shoulders metallic green; dorsal margin and about the ventral half of the mesinfraepisterna pale, the remainder metallic green; remainder of the mesopleura and metapleura except a green triangle adjacent to the wing base on the metepimera, buff or pale blue; postcoxal areas buff or pale blue; legs pale, striped with black; coxae and trochanters pale, all the femora with dorsal stripes extending from the apices nearly to the bases, and the front femora with a short cephalo-

ventral stripe including the cephalo-ventral row of setae; tibiae with long dorsal stripes extending from a point slightly distad of the femora to near the apices of the segments; tarsi and claws pale except at the apices; wings short, the postnodal cross-veins ten in the front wing, nine in the hind wing; M_2 arising between the fourth and fifth postnodal cross-veins in the front wing and between three and four in the hind wing.

Abdomen metallic green and pale blue; terga 1–7, inclusive, metallic green above, with broad, lateral, pale stripes on one and two, and narrow lateral stripes and interrupted basal rings on 3–7; eighth tergum green on the dorsum except at the apex, where there is a triangle of blue, the lateral angles of which are continuous with the broad blue stripes on the lateral surfaces; ninth and tenth terga blue with green basal triangles on each side of the meson; anal appendages (Figs. 159, 160) with the superiors small and tuberculate, the inferiors much larger than the superiors and toothed at the apices.

Female.—Color, metallic green or bronze, and yellow.

Head similar to that of the male except that within the dark area of the front there is a pale spot ventrad of each antennal fossa.

Thorax differing from that of the male in having the caudal lobe of the pronotum emarginate on each side of the meson, the piece being trilobed; the mesostigmal plates (Fig. 182) have the mesal margins strongly elevated and projecting dorsad; the front wings have nine to ten postnodal cross-veins, the hind wings usually nine.

Abdomen with terga 1–8, inclusive, greenish bronze, the lateral margins pale; ninth tergum green above, with an apical blue triangle and blue lateral stripes; tergum ten blue, with two small green triangles at the base; anal appendages of the usual type; ovipositor, including prostyles, extending beyond the apices of the anal appendages, the prostyles dark.

Measurements

Length, ♂	27 mm.
Length, ♀	26 mm.
Length of abdomen, ♂	21.5 mm.
Length of abdomen, ♀	21 mm.
Length of hind wings, ♂	15 mm.
Length of hind wings, ♀	15 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4 mm.

The species is apparently limited to the northern third of the state. It was abundant at Lake Villa, July 13, 1915, and was also taken at Freeport July 8, 1915.

Genus Amphiagrion Selys

The nymph of the only species of the genus known to occur in Illinois is easily distinguished from other genera by means of the projecting caudo-lateral angles of the head. The gills are without cuticular pigment and are decidedly ovate in shape.

The adults are red or brown in color. The stigma of both front and hind wings is turned obliquely to the long axis of the wing and the width is much greater than its length. The eighth sternum of the female possesses a long seta, and the sternites at the base of the cephalic pair of gonapophyses are small but visible with moderate magnification. The superior anal appendages of the male are much shorter than the inferiors and the parameres of the ninth sternum do not reach the apex.

Amphiagrion saucium (Burmeister)

Nymph.—Color, dark brown.

Head pentagonal and characterized by having the caudo-lateral angles projecting strongly and forming a short blunt tubercle; antennae composed of seven segments, the distal segments being short and similar to those of the nymphs of the genus Argia; labium broad, when folded extending to the metacoxae, the median lobe with three or four mental setae and six lateral setae, and the margins of the median lobe with ten to twelve setae.

Thorax brown; legs without brown rings and uniform in color; femora indistinctly carinate; tibiae with rather closely set slender setae; wing-cases extending caudad to the fourth or fifth abdominal segment.

Abdomen thickset, the lateral keels absent or feebly developed and without setae; ovipositor of the female nearly reaching the apex of the tenth segment in full-grown nymphs; caudal gills (Fig. 59) transparent, ovate-lanceolate, the apices gradually narrowed to a sharp point; margins of the gills setose from the proximal to the distal end, the setae placed closely together and increasing in length towards the apices; tracheal trunks sometimes subdividing and forming a number of large branches near the proximal fourth of the gill.

Measurements

Length	11–14 mm.
Length of abdomen	7–10 mm.
Length of gills	4.5 mm.
Width of gills	1.5 mm.

Length of metathoracic wing-cases. . .3.5 mm.
Length of median lobe. . . . . .1.75–2.0 mm.
Width of median lobe . . . . .1.25–1.5 mm.

Described from a single specimen taken at Muncie, Ill., April 25, 1914, and several specimens obtained from Dr. J. G. Needham, collected at Galesburg, Ill., June 3, 1897.

Adult; Male.—Color, very dark brown and deep orange-red.

Head black or dark above, pale below; labium pale, the median lobe subtriangular, the cleft shallow and broad at the base; antennae dark brown, the first two segments subequal in length, the first with a pale apical ring; postclypeus dark brown; anteclypeus, labrum, exposed portions of the mandibles, their trochantins, genae, and a transverse stripe on the front above the fronto-clypeal suture, pale buff, the pale area of the front extending dorsad along the margins of the compound eyes to the level of the antennal fossae; remainder of the front and vertex very dark brown, nearly black; occiput and postgenae pale.

Thorax dark brown to brick-red and yellowish buff; pronotum dark; proepimera also dark, nearly black; dorsum of the mesothorax, including the supraepisterna and the epimera and the caudo-dorsal angles of the metepisterna, black or dark brown; remainder of the meso- and metathorax yellowish red; intersternum projecting ventrad, conspicuous from the side, and provided with long black setae; legs yellowish buff, the coxae and trochanters yellowish, the femora slightly darker above but without distinct stripes; tibiae entirely pale and the tarsi pale except at the tips; femora with rounded dorsal carinae; wings with ten postnodal cross-veins in the front wing and about eight in the hind wing; M_2 arising between the fourth and fifth postnodal cross-veins in the front wing and between the third and fourth in the hind one; stigma reddish, small, surmounting a single cell.

Abdomen red and black; terga 1–6 dull red, with the exception of small caudo-lateral black spots on the dorsum of 1–6 inclusive, and subapical spots on five and six; terga 7–10 black on the dorsum, the lateral margins and a broad basal ring on seven reddish; anal appendages (Figs. 174,178) reddish, the superiors shorter than the inferiors, flat and the dorsal surface depressed; inferiors longer, acute, subconical, the tips directed dorso-mesad; apical margins of the tenth tergum emarginate on the dorso-meson and depressed at this point, forming a deep rounded pit.

Female.—Color in general similar to that of the male but usually considerably lighter.

Head similar to that of the male but lighter in color.

Thorax buff, and not blackish on the dorsum as in the male; mesostigmal plates as shown in Figure 181.

Abdomen: terga 1–4 red; terga 5–7 red with two black spots on each near the caudal fourth; terga eight and nine with two longitudinal black stripes extending from the cephalic margins to within a very short distance of the caudal margins; tergum ten pale buff; sterna 1–10 buff; eighth sternum with a long seta; ovipositor with broad, buff, lateral valves, the ventral margins serrate; prostyles short, brown.

Measurements

Length, ♂	26 mm.
Length, ♀	26 mm.
Length of abdomen, ♂	21 mm.
Length of abdomen, ♀	21 mm.
Length of hind wings, ♂	16 mm.
Length of hind wings, ♀	16 mm.
Width of hind wings, ♂	3.5 mm.
Width of hind wings, ♀	3.5 mm.

Adults have been collected at Urbana during the latter part of May and early part of June, but the species has at no time appeared in great abundance, and attempts to secure the nymphs from this locality have failed.

Genus Chromagrion Needham

The nymphs of this genus are characterized by the projecting caudo-lateral angles of the head and the extremely long and slender gills, which are without conspicuous marginal setae. The median lobe of the mentum is provided with mental setae and the proximal segments of the labial palpi have a single sharp fixed hook and a blunt process with teeth at the apex. The lateral keels are not well developed and are without heavy setae.

The adult is characterized by the absence of postocular spots, by the long, somewhat forcipate, anal appendages of the male, and by the peculiar formation of the pronotum of the female—as shown in Figure 170. The parameres of the male extend to the apex of the ninth sternum.

The genus is represented in North America by a single species.

Chromagrion conditum (Hagen)

Nymph.—Color, dark brown.

Head half as long as wide, the caudo-lateral angles projecting strongly; labium, when folded, extending caudad to the procoxae; mental setae three and sometimes a small fourth; lateral setae five; proximal segment of the palpus with a distinct hook at the apex of the mesal process and the median lobe with a slight notch at the apex.

Thorax: femora with two dark rings and a double row of setae on the ventral surfaces; tibiae with a single basal ring of brown; wing-cases reaching caudad to the fifth abdominal segment.

Abdomen slender; lateral keels feebly developed and without setae; gills long and slender, widening gradually to near the apices, then suddenly contracted, the margins setose, the setae far apart and increasing in size distad; color of gills uniform dark brown, except that the tips are light; indistinct blotches of darker pigment occur around the margins of the gills; smaller tracheae transparent and indistinct.

Measurements

Length	17 mm.
Length of abdomen	10 mm.
Length of gills	6 mm.
Width of gills	1 mm.
Length of median lobe	2 mm.
Width of median lobe	.6–1.6 mm.

Described from fragments of several exuvia obtained from Dr. J. G. Needham, and the description completed from data given by Needham in his description of the species ('03: 247).

Adult; Male.—Color, blue, black, and yellowish orange.

Head black and dark brown and buff; mouth-parts yellowish, the labium pale, the median lobe subtriangular in outline, the cleft broad and deep; labial palpi pale, the distal segment also pale; antennae nearly black, the first segment nearly as long as the second; postclypeus black, the anteclypeus, labrum, mandibles, their trochantins, genae, and the front above the clypeus to the level of the antennal fossae, greenish blue; remainder of the vertex, occiput, and postgenae black.

Thorax black and blue, the pronotum largely black, the cephalic lobe, a small spot on the lateral margins of the median lobes, and the lateral margins of the caudal lobe, pale; proepimera and proepisterna bluish green, the dorsal borders black; mesostigmal plates long and triangular, the lateral angles pale; mesepisterna with a

broad black stripe which, adjoining the wing bases, is exactly the width of the two mesepisterna together, but contracts suddenly shortly cephalad of this, and again about half-way to the cephalic margin of the mesothorax; mesinfraepisternum with an indefinite black spot on the cephalic border; caudal margins of the mesepimera and metepisterna black, shining, the sclerites themselves pale blue; metepimera lemon-yellow, the cephalic half of the ventral margins frequently dark; post-coxal areas yellowish buff, lateral margins of the intersternum darker; legs black and greenish buff, the coxae usually black on the cephalic surfaces; trochanters black on the dorsum, the femora with a broad, shining black, dorsal stripe, which encircles the segment at the apex and is narrowed basally on the front femora; femoral setae of the front femora, seven and four in the two rows respectively; tibiae pale buff, with a darker stripe on the ventral surfaces between the rows of setae, the tips dark; tarsi shining black; wings with eleven postnodal cross-veins in the front wing and ten to eleven in the hind one; stigma surmounting a single cell and much longer than broad.

Abdomen blue and black, the first tergum with a short basal black spot on the dorsum and latero-cephalic angles; terga 2–6, inclusive, blue with cephalo-lateral spots of black; second tergum with an apical shield-shaped spot and an apical ring; terga 3–6 with dorsal longitudinal stripes, narrowed to a line at the cephalic margins and widened to the lateral margins at the caudal end of the segment; terga eight and nine blue, with narrow lateral stripes on the lateral margins and mesal stripes from the base to the distal fourth and small spots on each side of the distal extremity of the lines; tenth segment entirely black except the small blue spots on the dorsum, one on each side of the meson; first sternum pale, with a black median spot, 2–9 black; anal appendages (Figs. 102,106) black, the superior appendages longer than the inferiors, slightly swollen at the apices, and the mesal surfaces densely hairy; inferiors short, pointed at the tip, the dorsal surface flat, the ventral surfaces convex.

Female.—Color: the blue of the male is replaced by yellowish buff; the yellow is the same as that of the male.

Head similar to that of the male.

Thorax: pronotum curiously modified, the caudal margins of the caudal lobe not continuous (Fig. 170) and the median lobe with a flat lateral projection on each side; proepimera entirely pale; meso-stigmal plates broad, the caudal margins convex, the lateral angles more or less acute, and the latero-caudal margins slightly elevated.

Abdomen buff and black, the first tergum with a black basal spot and a cephalo-lateral spot on each side; dorsum of the second tergum

with a broad black band from the base to the apex which is widened subapically, and a narrow apical ring; terga 3–7 with small dark spots near the cephalo-lateral angles, broad dorsal longitudinal stripes, narrowed at the base but not to a line, and widened at the apex but not reaching the lateral margins of the sclerites except on terga five, six, and seven; terga 7–10 with pale lateral margins and black dorsal stripes, the stripes narrowed at the caudal end; anal appendages of the usual type; ovipositor short, brown, the prostyles short and blunt, the eighth sternites at the base of cephalic pair of gonapophyses large and subtriangular; sterna 2–7 black, the eighth with a black median line but without an apical spine.

Measurements

Length, ♂	35 mm.
Length, ♀	36 mm.
Length of abdomen, ♂	29 mm.
Length of abdomen, ♀	30 mm.
Length of hind wings, ♂	21 mm.
Length of hind wings, ♀	22 mm.
Width of hind wings, ♂	4 mm.
Width of hind wings, ♀	4 mm.

Described from a number of specimens in the collection of Mr. E. B. Williamson. Reported from northern Illinois by Needham ('03: 247).

Genus Ischnura Charpentier

The nymphs of this genus have gills with long tapering points and one or more arcuate cross-bands. The labium is moderately broad and the median lobe possesses four or five setae and five or six, usually six, lateral setae.

The adults may be distinguished from other genera by the presence of postocular spots, by the origin of vein M_2, which is between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind wing, and by the presence in the males of a short apical projection of the dorsum of the tenth tergum, which is, however, not as long as the segment. The sternites at the base of the cephalic pair of gonapophyses of the female are very small and do not project beyond the caudal margin of the large basal sternite of the eighth segment. The parameres of the male do not extend caudad to the margin of the ninth segment and the anal appendages are short, the superiors being about as long as, or shorter than, the inferior appendages.

Key to Species

NYMPHS

a. Gills with four distinct arcuate cross-bands and a blotch on the tip of the gill; dorsal marginal setae of the median gill extending one-third the length of the gill from the base; lateral setae of the labium, five . . ..*posita.*

aa. Gills with one or two cross-bands or none, never with four; dorsal marginal setae of the median gill extending one-half the length of the gill from the base; lateral setae of the labium usually six. .*verticalis.*

ADULTS

a. Mesopleural pale stripe of the supraepisterna interrupted at the caudal third and forming a distinct exclamation point; eighth sternum of the female with a long spine..............................*posita.*

aa. Mesopleural pale stripe of the supraepisterna not interrupted at the caudal third and not forming a distinct exclamation point; eighth sternum of the female without a long spine.

b. Seventh tergum with more or less blue on the dorsum....*kellicotti.*

bb. Seventh tergum black on the dorsum..................*verticalis.*

Ischnura kellicotti Williamson

Nymph.—Unknown.

Adult; Male.—Color, blue and black.

Head blue and black; labium pale buff, the median lobe subtriangular; labial palpi broad, the second segment pale; antennae dark brown, with a small pale blue spot on the condyle of the scape; postclypeus black, anteclypeus blue; labrum blue except a black dorsal marginal line; exposed portions of the mandibles, their trochantins, genae, and the front above the fronto-clypeal suture to the antennal fossae, blue; the blue area of the front is divided by a short black line on the meson and the blue color extends dorsad above the genae to the antennal fossae; remainder of the front and the vertex black; postocular spots large and blue and connected with the blue of the occiput; occiput and postgenae except medium-sized black spots on each side of the occipital foramen, pale blue.

Thorax blue and black; pronotum largely black, the cephalic lobe, caudal margin of the caudal lobe, and four small spots on the median lobe, near the meson, blue; proepimera blue and black, the caudal half being largely blue; mesostigmal plates with blue lateral angles; mesothorax with black supraepisterna which possess narrow longitudinal blue stripes, the stripes narrowed conspicuously at the middle

and widened at both ends but not extending caudad to the paraptera; dorsal half of the mesepimera black, the black stripe covering that portion suddenly widened by a ventral projection just caudad of the mesinfraepisternum; mesinfraepisterna black except the caudo-ventral angles; remainder of the pleura blue, the interpleural fold and the metapleural suture, however, lined with black; postcoxal areas mostly pale; legs blue and black; coxae largely blue, the cephalic surfaces sometimes spotted with black; trochanters blue, black above; femora with broad dorsal stripes, blue beneath; tibiae, tarsi, and claws brown and without stripes; wings with eight or nine postnodal cross-veins in the front wing and seven in the hind wing; stigma subelliptical, black or blue in the front wing, pale in the hind wing; M_2 arising between the third and fourth postnodal cross-veins in both wings.

Abdomen black, blue, and buff; first tergum blue with the cephalic half black; second, blue with a broad black lateral stripe on each side and a narrow apical ring, the stripes extending from the base of the segment to the caudal third and the two uniting on the meson at the caudal ends; terga 3–6 black, with narrow, blue, interrupted basal ring and lateral marginal stripes; seventh tergum black with pale lateral stripes and a blue apical spot on the dorsum; eighth and ninth terga blue with broad, black, lateral stripes; tenth tergum black, occasionally with indefinite blue dorsal spots; anal appendages dark, the superiors broad, laterally compressed and the ventro-mesal angles hook-like; inferiors slightly longer than the superiors, subconical, the tips black; sterna 1–10 black.

Female.—Color similar to that of the male.

Head similar to that of the male except that the pale area of the front is not divided by the mesal black line.

Thorax: the blue of the male is replaced by buff; pale spots of the pronotum large and occupying nearly the whole of it; pale stripe of the mesosupraepisterna extending caudad to the paraptera; legs similar to those of the male, but usually paler in color; stigma of both wings brown.

Abdomen: first tergum similar to that of the male; second, blue, with a dorsal black spot near the caudal margin and the lateral margins pale; terga 3–6 black with pale lateral margins; terga 7–10 pale blue with black lateral margins; anal appendages of the usual type; ovipositor with broad lateral styles.

Measurements

Length, ♂ . . . . 32 mm.
Length, ♀ . . . . 31 mm.

Length of abdomen, ♂ . . . . 25 mm.
Length of abdomen, ♀ . . . . 25 mm.
Length of hind wings, ♂ . . . . 27 mm.
Length of hind wings, ♀ . . . . 28 mm.
Width of hind wings, ♂ . . . . 3.5 mm.
Width of hind wings, ♀ . . . . 3.5 mm.

This species has not been taken in Illinois, but has been collected in Indiana by Mr. Williamson, and the above description has been made from specimens in his collection.

Ischnura posita (Hagen)

Nymph.—Color, usually dark brown.

Head oval or elliptical in outline, the caudo-lateral angles not projecting and with only a few setae; antennae of the usual form, the first two segments dark in color, the second light at the tip; labium extending between or slightly caudad of the procoxae; mental setae four and sometimes a small fifth on each side; lateral setae five; lateral marginal setae of the median lobe four.

Thorax about equal in diameter throughout; femora with rows of setae which become heavier towards the apices; tarsi pale, the apices of the third segments brown; metathoracic wing-cases extending caudad to the fourth abdominal segment.

Abdomen: cuticle provided with numerous black spots usually bearing a single minute seta; lateral keels without setae except those of the caudal segments; gills lanceolate (Figs. 64, 66), broadest beyond the middle, usually with four crescentic brownish bands of which the apical ones are somewhat paler than the proximal, the median gill with a dorsal row of about fourteen setae extending one-third the length of the gill from the base; ovipositor extending to the apex of the tenth abdominal segment.

Measurements

Length . . . . 11.5 mm.
Length of abdomen . . . . 7.5 mm.
Length of gills . . . . 5–5.5 mm.
Width of gills . . . . 1.6 mm.
Length of metathoracic wing-cases . . 3.0 mm.
Length of median lobe . . . . 2.0 mm.
Width of median lobe . . . . .5–1.6 mm.

The nymph is very closely related to *verticalis* but may be separated from the latter by means of the shape and figuration of the

gills. The lateral setae of the labium do not often exceed five, whereas there are usually six in *verticalis*.

Adult; Male.—Color, black and sulphur-yellow.

Head black and yellow; mouth-parts buff, the median lobe subtriangular; palpi narrow, the distal segment pale; antennae uniform dark brown, the second segment considerably longer than the first; postclypeus shining black; anteclypeus pale, labrum pale, with a transverse dorsal black stripe which has a slight ventral projection on the meson; remainder of the labrum, exposed portions of the mandibles and their trochantins, genae, and the front dorsad of the fronto-clypeal suture to the level of the antennal fossae, shining yellow; remainder of the front and vertex black, the postocular spots yellow and circular; a short yellow line caudad of the ocelli; postgenae and occiput yellow.

Thorax black and yellow; pronotum black except the cephalic lobe, which is yellow; caudal lobe with yellow spots on the lateral angles; mesostigmal plates with large oval yellow spots; mesosupraepisterna with short yellow stripes and spots adjacent to the paraptera, the two together forming an exclamation point on each side of the dorsal carina; black stripe covering the mesopleural suture on each pleuron contracted near the wing bases; dorsal half of the mesinfraepisterna and a stripe on the metapleural sutures black, the remainder of the metathorax and the postcoxal areas yellow; legs black and yellow, the coxae, trochanters, and femora pale, the femora with a dorsal stripe on each from base to apex, the stripe widened subapically; tibiae with a dorsal black stripe from base to apex which fades into brown towards the apex; tarsi and claws pale, darker at the tips; wings short, the postnodal cross-veins six to eight and M_2 arising between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind wing.

Abdomen black and yellow; terga 1–10 dull black with the exception of a narrow basal ring on segments 3–7, the stripes narrowed conspicuously on two and widened on the apices of segments 3–6 inclusive; lateral margins of all terga pale yellow; sterna 3–8 lined with black on the meson; apex of the tenth tergum with a mesal elevation at the apex, the elevated portion forming two small tubercles; anal appendages (Figs. 173,177) small, orange, the superiors large and blunt and bent ventrad, the inferiors also large, blunt, and bifurcate, the arms feebly divaricate and the dorsal arm with a number of heavily chitinized teeth.

Female.—Color, pale blue and black.

Head similar to that of the male except that the postocular spots are blue.

Thorax pale blue and black, lacking the black stripes on the metapleural sutures, and the femoral black stripes almost wanting or reduced to short subapical lines.

Abdomen with the pale and black markings similar to those of the male; anal appendages of the usual type, the ovipositor with prostyles extending caudad to the apex of the anal appendages.

Measurements

Length, ♂	24 mm.
Length, ♀	29 mm.
Length of abdomen, ♂	19 mm.
Length of abdomen, ♀	18–22 mm.
Length of hind wings, ♂	12 mm.
Length of hind wings, ♀	13–16 mm.
Width of hind wings, ♂	2.5 mm.
Width of hind wings, ♀	2.5–3.5 mm.

A common species in southern and central Illinois, occurring in the same localities where *verticalis* is abundant. The adults appear usually somewhat later than *verticalis*, and the earliest reared specimens in my collection bear the date June 12, 1915.

Specimens have been seen from Havana, Peoria, and Urbana.

Ischnura verticalis (Say)

Nymph.—Color, pale green, buff, or dark brown.

Head broader than long, subelliptical, the caudo-lateral angles with strong setae; antennae with the first two segments and the proximal third of three dark, the remainder pale; first two segments subequal, the third as long as the first two together; labium, when folded, extending slightly caudad of the procoxae, with four or five mental setae and six lateral setae, the lateral marginal setae of the median lobe six or seven in number.

Thorax nearly equal in diameter throughout; front femora with a strong row of setae on the cephalic surface and all the femora with preapical rings of brown; tibiae with several rows of apical setae, two of which extend far proximad; wing-cases extending caudad to the fourth abdominal segment.

Abdomen cylindrical and with feeble lateral keels on segments 1–8, the margins and ventral surfaces being thickly studded with short setae; cuticle of the abdomen with small dark spots from which minute setae usually arise, one to each spot; gills (Figs. 62, 65) with long

tapering points, the dorsal marginal setae of the median gill usually extending nearly half the length of the gill from the base, the ventral row of the same gill consisting of about seven strong setae, considerably farther apart than those of the dorsal row; ventral marginal setae of the lateral gills extending slightly farther from the base of the gills than the dorsal row of the median gill; pigment of the gills in the form of one or two arcuate cross-bands near the middle of the gill; these, however, may be wanting; ovipositor extending to the middle of the tenth abdominal sternum.

Measurements

Length	13–14 mm.
Length of abdomen	9–10 mm.
Length of gills	6–7 mm.
Width of gills	1–1.3 mm.
Length of median lobe	1.8 mm.
Width of median lobe	.6–1.6 mm.

Adult; Male.—Color, black or dark metallic green and pale green.

Head black and yellowish green; mouth-parts buff, the median lobe of the labium subtriangular, the cleft short and acute at the proximal end; antennae black or very dark brown; postclypeus black, shining; anteclypeus, labrum, exposed portion of the mandibles and their trochantins, genae, and the front above the clypeus, yellow; postocular spots large and subcircular; vertex, and front except the stripe above the clypeus, dull black; occiput black and greenish yellow.

Thorax greenish black and greenish yellow; pronotum shining black with a transverse yellow stripe on the cephalic lobe; caudal lobe of the pronotum with a distinct transverse carina; noto-epimeral suture indistinct, the proepimera and episterna largely yellow; mesothorax shining black with a yellow stripe just above the mesopleural suture; ventral half and cephalic shoulder of the mesepimera yellow; paraptera trapezoidal, with a yellow spot just ventrad of the lateral angles, the remainder black; mesostigmal plates black, the caudal margins elevated and lined with yellow; metathorax including the postcoxal areas, pale green or yellowish; legs black and yellow, the coxae and trochanters pale with some darker marks on the sutures; femora all with a broad dorsal stripe, the tibiae with narrower dorsal stripes extending from near the bases to near the apices; tarsi and claws pale, dark at the tips; wings short, the postnodal cross-veins seven to nine, and M_2 arising between the third and fourth postnodal cross-veins in the front wing and between the second and third in the hind wing.

Abdomen shining black or green, and yellowish green; dorsum of terga 1–7, inclusive, shining black or green with narrow apical ring on the first, interrupted basal rings on 3–6, and the lateral margins of 1–6 yellow; dorsum of terga eight and nine blue, with short lateral black stripes on each side about half the length of the segment; tergum ten black, the lateral margins pale, the caudal margin with a short forked process on the meson; sterna 3–9 with a mesal line of black; anal appendages (Fig. 168) short, the superiors flat and placed nearly vertically; inferiors longer, and with a dorsal, basal knob and a larger, subconical ventral lobe.

Female.—Color, orange and black or entirely black.

Head similar to that of the male except that the yellowish green markings are replaced with orange.

Thorax orange and black; pronotum with an orange spot on each median lobe; margin of the caudal lobe with orange spots; mesostigmal plates (Fig. 180) with caudal elevated margins orange in color; mesopleural pale stripe of the supraepisterna orange and much broader than the pale stripe of the male; dorsal third and caudal margin of the mesinfraepisterna black, the remainder pale orange; metathorax orange; legs orange and black, the femora entirely pale except at the tips, the tibiae with the usual dorsal stripes.

Abdomen orange and black, the first two segments entirely pale except a narrow ring on the caudal margin of the second; terga three orange with an apical spot and ring; dorsum of terga 4–8 black, with pale basal rings on 4–6 and the apical third of eight also pale; terga nine and ten indefinitely marked with black, there being an orange spot and apical ring of orange on nine and a dorso-mesal line on the same; lateral margins of all the terga orange; sterna 1–8, inclusive, with a mesal black line, the eighth sternum with a heavy spine; anal appendages of the usual type; the ovipositor with dark brown prostyles and pale lateral valves.

In older specimens the orange color becomes black and pollinose so that it is difficult to distinguish the species on the wing from some of the Enallagmas which also have a tendency to become dark.

Measurements

Length, ♂ ....20 mm.
Length, ♀ ....30 mm.
Length of abdomen, ♂ ....22 mm.
Length of abdomen, ♀ ....23–24 mm.
Length of hind wings, ♂ ....14 mm.
Length of hind wings, ♀ ....17 mm.
Width of hind wings, ♂ ....3.5 mm.
Width of hind wings, ♀ ....3.5 mm.

The commonest species in Illinois, occurring practically wherever there is enough permanent water for the nymphs to live. The adults appear early in May and continue to emerge until September and possibly later.

Specimens have been seen from Dubois, Carbondale, Golconda, Havana, Lake Villa, Mahomet, Muncie, Peoria, Urbana, and Vienna.

Genus Anomalagrion Selys

The nymphs of this genus are characterized by their unusually small size, by the presence of a very slender tip to the gills, and by the absence of setae on the lateral keels.

The male adults are unique in having the stigma of the front wing removed from the margin and in the possession of a long process on the dorsum of segment ten. The sternites at the base of the cephalic pair of gonapophyses of the female are wanting, and the parameres of the ninth sternum of the male do not reach the apex of the segment.

Anomalagrion hastatum (Say)

Nymph.—Color, green or buff.

Head with the caudo-lateral angles rounded and without setae; antennae with the first two segments dark brown, the remaining ones light in color; second segment about as long as the first or slightly longer; labium not extending caudad of the procoxae and about as broad as long; mental setae four, lateral setae five.

Thorax narrower than the head; legs without dark rings and with few setae, the tibiae with the usual apical scales; wing-cases extending nearly to the fourth abdominal segment.

Abdomen uniform in color; lateral keels feebly developed and without setae; gills (Fig. 60) lanceolate, with a long point; marginal setae of the median gill consisting of a thick dorsal row, extending about one-third the length of the gill from the base, and a scattered ventral row at the base; ventral marginal row of setae of the lateral gills slightly longer than the dorsal row of the median gill; ovipositor extending to the caudal margin of the tenth abdominal sternum.

Measurements

Length	9.5 mm.
Length of abdomen	5.5 mm.
Length of gills	4.5 mm.
Width of gills	1.0 mm.
Length of median lobe	1.6 mm.
Width of median lobe	0.5–2.0 mm.

Adult; Male.—Color, pale lemon-yellow and black.

Head lemon-yellow and metallic black; mouth-parts buff, the median lobe with a wide cleft which is obtuse at the proximal end; antennae dark brown except the proximal segment, which has a pale stripe from the base to the apex; postclypeus shining black; anteclypeus pale; labrum with a transverse black stripe on the dorsal margin, the remainder yellow; exposed portions of the mandibles, their trochantins, the genae, and the front above the fronto-clypeal suture to the antennal fossae, yellow; remainder of the front and the vertex metallic bronze with the exception of very small postocular spots, a small yellow spot ventrad of the median ocellus, and a narrow yellow stripe caudad of the ocellar area.

Thorax greenish yellow and metallic black; cephalic lobe of the pronotum with a yellow transverse stripe; median lobes metallic black; caudal lobe black with three short marginal dashes; noto-epimeral suture indistinct; dorsal carina of the mesothorax feebly developed. the mesothorax largely black with a narrow yellow line just dorsad of the mesopleural suture; dorsal half of the mesosupraepisterna black; metepisterna and epimera yellow or buff; paraptera trapezoidal, the cephalic margins with a pale line; coxae pale yellow, the femora pale, with dorsal black stripes widened distad; tibiae pale, with short, proximal, dorsal and ventral dark stripes, the tarsi and claws pale except at the tips; setae of the front femora few, about three in each row, the distance between them much greater than their length; wings (Figs. 82, 83) very short; postnodal cross-veins six in the front wing and five in the hind; M_2 arising near the third postnodal vein in the front wing and between the second and third in the hind wing; stigma of the front wing ovoid, remote from the margin, the stigma of the hind wing rhomboidal and in contact with the margin of the wing.

Abdomen yellow and orange, the black confined to longitudinal dorsal bands on terga 1–3 and six, the stripe on three and the one on six being conspicuously widened subapically; basal and apical black spots present on the fourth and fifth terga, and a dorsal stripe on seven which is about three-fourths the length of the segment; the narrow basal ring on segments 1–7 is interrupted on the meson in all except the first; tenth tergum with a dorsal process about as long as the segment and bifurcate at the apex; anal appendages (Figs. 166, 167) small, the superiors bifurcate, and with a broad mesal lobe extending caudo-ventrad and a conical lateral one projecting caudad; inferiors conical, slightly longer than the superiors.

Female.—Color, orange and black or dark brown.

Head orange and black, differing from that of the male in having the black of the postclypeus reduced to a dorsal line and that of the labrum to lateral spots; postocular spots wanting, the caudal margins of the head with a broad orange stripe; occiput and postgenae pale.

Thorax: prothorax as in the male except that the black of the pronotum does not extend as far onto the lateral aspect; dorsal black stripe of the mesothorax extending on each side of the dorsal carina one-half the width of the supraepisterna; mesopleural suture with a black line, the remainder of the thorax orange and buff; mesostigmal plates as shown in Figure 164.

Abdomen orange, with narrow basal black rings on terga 2–4 inclusive, a longitudinal dark stripe on the caudal three-fourths of five, similar stripes extending the full length of six, seven, and eight, and two triangular spots at the base of the ninth; dorsum of the tenth tergum with a short blunt projection; anal appendages short; ovipositor long and extending caudad of the anal appendages; prostyles short and blunt.

Measurements

Length, ♂	23 mm.
Length, ♀	24.5 mm.
Length of abdomen, ♂	17 mm.
Length of abdomen, ♀	19 mm.
Length of hind wings, ♂	10.5 mm.
Length of hind wings, ♀	14 mm.
Width of hind wings, ♂	1 mm.
Width of hind wings, ♀	2–2.5 mm.

This species is rather more common in the southern half of the state than in the northern. It appears on the wing as early as June 20 at Urbana, but has been taken at Carmi, June 14, 1915.

Bibliography

The following bibliography has been made as complete as possible in literature dealing with the nymphs. The remaining portion is intended to include the works referred to in the preceding pages and also the more important systematic publications, such as monographs and catalogues. To persons beginning a study of the Odonata, Muttkowski's "Catalogue of the Odonata of North America" and Calvert's "Progress in our Knowledge of the Odonata from 1895 to 1912" should be considered indispensable. In these two works, most of the literature appearing previous to 1912 is cited. A number of important

articles have appeared since that date, and an attempt has also been made to include these in this bibliography.

NYMPHS

Backhoff, Paul
'10. Die Entwicklung des Copulationsapparates von Agrion. Ein Beitrag zur postembryonalen Entwicklungsgeschichte der Odonaten. Zeit. wiss. Zool., 95 : 647–706, pl. 21.

Balfour-Browne, F.
'09. Life-history of the agrionid dragonfly. Proc. Zool. Soc. London, 1909 : 253–285, pls. 23, 24.

Bervoets, R.
'13. Sur le système trachéen des larves d'Odonates. Ann. Biol. Lacustre, 6 : 15–32, figs. 1–3.

Börner, C.
'09. Neue Homologien zwischen Crustaceen und Hexapoden. Die Beissmandibel der Insekten und ihre phylogenetische Bedeutung. Archi- und Metapterygota. Zool. Anz., 34 : 100–125.

Brimley, C. S.
'04. Note on duration of larval stage of Odonata. Ent. News, 15 : 136.

Butler, Hortense
'04. The labium of the Odonata. Trans. Am. Ent. Soc., 30 : 111–134, pls. 2–7.

Calvert, P. P.
'00. Moults in the Odonata. Entomologist, 33 : 350.
'11. Studies on Costa Rican Odonata. Ent. News, 22 : 49–64, pls. 2, 3.
'15. Studies on Costa Rican Odonata. Ent. News, 26 : 385–395, pls. 15–17.

Forbes, S. A.
'88. On the food relations of fresh-water fishes. Bull. Ill. State Lab. Nat. Hist., 2 : 485.

Gilson, G., and Sadones, J.
'96. Larval gills of Odonata. Trans. Linn. Soc. London, 25 : 413.

Hagen, H.
'80. Essai d'un synopsis des larves des Caloptérygines. Ann. de la Soc. Ent. de Belgique, 23 : LXV–LXVII.

Heymons, R.

'96. Grundzüge der Entwickelung und des Körperbaues von Odonaten und Ephemeriden. Anhang zu den Abhandl. Königl. Preuss. Akad. Wiss. Berlin, 1896. 66 pp., pls. 1, 2.

'04. Die Hinterleibsanhänge der Libellen und ihrer Larven. Ann. k.k Naturhist. Hofmus., 19: 21–58, pl. 1.

Kennedy, C. H.

'15. Notes on the life history and ecology of dragonflies (Odonata) of Washington and Oregon. Proc. U. S. Nat. Mus., 49: 259–345.

Lucas, W. J.

'12. Early stages of British Odonata. Rep. Lancash. Ent. Soc., 35: 17–24.

Lyon, Mary B.

'15. The ecology of the dragon-fly nymphs of Cascadilla Creek. Ent. News, 26: 1–15, pl. 1.

Needham, J. G.

'03. Life histories of Odonata, suborder Zygoptera. Damsel flies. Bull. N. Y. State Mus., 68: 218–279, pls. 11–19.

'11. Descriptions of dragonfly nymphs of the subfamily Calopteryginae. Ent. News, 22: 145–154, pls. 4, 5.

'11a. Notes on a few nymphs of Agrioninae (order Odonata) of the Hagen collection. Ent. News, 22: 342–345, pl. 11.

Pierre, l'Abbé

'04. Sur l'éclosion des œufs de *Lestes viridis*. Ann. Soc. Ent. France, 73: 477–484, pl. 4.

Riley, C. F. C.

'12. Observations on the ecology of dragon-fly nymphs: reactions to light and contact. Ann. Ent. Soc. Amer., 5: 273–292.

Ris, F.

'09. Odonata. Die Süsswasserfauna Deutschlands, Heft 9.

Rousseau, E.

'09. Étude monographique des larves des Odonates d'Europe. Ann. Biol. Lacustre, 3: 300–366, figs. 1–47.

Sadones, J.

'95. L'appareil digestif et respiratoire larvaire des Odonates. La Cellule, 11: 273–324, pls. 1–3.

Tillyard, R. J.
'06. Life history of *Lestes leda* Selys. Proc. Linn. Soc. N. S. Wales, 31: 409–423, pls. 32, 33.
'11. On the genus Cordulephya. Proc. Linn. Soc. N. S. Wales, 36: 388–422, pls. 11, 12.
'12. On the genus Diphlebia, with descriptions of new species and life histories. Proc. Linn. Soc. N. S. Wales, 36: 584–604, pls. 19–20.

Van der Weele, H. W.
'06. Morphologie und Entwicklung der Gonapophysen der Odonaten. Tijdschr. v. Ent., 49: 99–198, pls. 6–8.

Walker, E. M.
'13. New nymphs of Canadian Odonata. Can. Ent., 45: 161–170, pls. 1, 2.
'14. The known nymphs of the Canadian species of Lestes. Can. Ent., 46: 189–200, pls. 13, 14.
'14a. New and little-known nymphs of Canadian Odonata. Can. Ent., 46: 349–357, 370–377, pls. 23, 25.

Warren, A.
'15. A study of the food habits of the Hawaiian dragonflies or pinau. College of Hawaii Publications, Bull. 3, pls. 1–4.

Wesenburg-Lund, C.
'13. Odonaten-Studien. International Revue, 6: 155–228, 373–422.

ADULTS

Banks, N.
'92. A synopsis, catalogue, and bibliography of the neuropteroid insects of temperate North America. Trans. Am. Ent. Soc., 19: 327–373.

Brandt, A.
'69. Beiträge zur Entwickelungsgeschichte der Libelluliden und Hemipteren, mit besonderen Berücksichtigung der Libelluliden. Mém. Acad. Imp. des Sci. St. Pétersb., ser. 7, 13: 1–33, pls. 1–3.

Brauer, F.
'68. Verzeichniss der bis jetzt bekannten Neuropteren im Sinne Linné's. Verhandl. d. k.-k. zool.-bot. Gesell. Wien, 18: 359–416, 711–742.

Calvert, P. P.
'93. Catalogue of the Odonata (dragonflies) of the vicinity of Philadelphia, with an introduction to the study of this group of insects. Trans. Am. Ent. Soc., 20: 152a–152d; 153–272, pls. 2, 3.
'08. The composition and ecological relations of the odonate fauna of Mexico and Central America. Proc. Acad. Nat. Sci. Phila., 60: 460–491.
'08a. Odonata. Biol. Centr.-Amer., Neuroptera, pp. V–XXX, 17–410, pls. 2–10.
'12. Progress in our knowledge of the Odonata from 1895–1912. Trans. Sec. Intern't'l Congr. of Ent., pp. 140–157.
'13. The species of Nehalennia (Odonata). Ent. News, 24: 310–316.
'13a. The fossil odonate Phenacolestes, with a discussion of the venation of the legion Podagrion Selys. Proc. Acad. Nat. Sci. Phila., 65: 225–272, pl. 14.

Calvert, P. P., and Hagen, H. A.
'02. (See Hagen and Calvert)

Hagen, H.
'61. Synopsis of the Neuroptera of North America, Smithsonian Miscellaneous Collections, 1861: 55–187.
'75. Synopsis of the Odonata of North America. Proc. Bost. Soc. Nat. Hist., 18: 20–96.

Hagen, H. A., and Calvert, P. P.
'02. Illustrations of Odonata: Argia, with a list and bibliography of the species. Bull. Mus. Comp. Zool., 39, No. 4: 103–120, pls. 1, 2.

Handlirsch, A.
'06–'08. Die Fossilen Insekten. 1430 pp., 51 pls. Leipzig.
'11. New Paleozoic insects from the vicinity of Mazon Creek, Illinois. Am. Jour. Sci., ser. 4, 31: 297–326.

Kellicott, D. S.
'99. The Odonata of Ohio. Ohio State Acad. Sci., Special Papers, No. 2. 114 pp., figs. 1–39.

Kennedy, C. H.
'02. A list of the dragonflies of Winona Lake. Proc. Ind. Acad. Sci., 1902: 159–164.
'02a. A new diagnostic character for the species of the genus Argia. Proc. Ind. Acad. Sci., 1902: 164–169, pls. 1, 2.

Kirby, W. F.
'90. Synonymic catalogue of Neuroptera Odonata, or dragonflies, with an appendix of fossil species. 202 pp. London and Berlin.

Lucas, W. J.
'00. British dragonflies (Odonata). 356 pp., 27 pls. London.

Marshall, W. S.
'14. On the anatomy of the dragonfly, *Libellula quadrimaculata* Linné. Trans. Wis. Acad. Sci., Arts, and Letters, 17, Pt. 2: 755–786, pls. 69, 70.

Morgan, Anna H.
'13. A contribution to the biology of the May-flies. Ann. Ent. Soc. Amer., 6: 371–413, pls. 42–54.

Muttkowski, R. A.
'08. Review of the dragon-flies of Wisconsin. Bull. Wis. Nat. Hist. Soc., n. s., 6: 57–123, pls. 4–6.
'10. Catalogue of the Odonata of North America. Bull. Pub. Mus. City of Milwaukee, Vol. 1, Art. 1. 207 pp.

Needham, J. G.
'03. A genealogic study of dragon-fly wing venation. Proc. U. S. Nat. Mus., 26: 703–764, pls. 31–54.

Packard, A. S.
'68. On the development of a dragon-fly (Diplax). Proc. Bost. Soc. Nat. Hist., 11: 365–372.

Poulton, E. B.
'06. Predaceous insects and their prey. Trans. Ent. Soc. London, 1906: 323–409.

Ridgway, R.
'12. Color standards and color nomenclature. 43 pp., 53 pls. Washington.

Ris, F.
'96. Untersuchung über die Gestalt des Kaumagens bei den Libellen und ihren larven. Zool. Jahrb., Abt. Syst. Geogr. u. Biol. Thiere, 9: 596–624.

Scudder, S. H.
'90. The tertiary insects of North America. Rep. U. S. Geol. Surv. Terr., XIII. 663 pp., 28 pls.

Sellards, E. H.
'06. Types of Permian insects. Am. Jour. Sci., ser. 4, 22: 249–258.

Selys-Longchamps, Edm. de
'62. Agrionines. 2[me] Légion.–Lestes. Bull. de l'Acad. Roy. des Sci., des Lettres, et des Beaux-Arts de Belgique, sér. 2, 13: 291–338.
'65. Synopsis des Agrionines–[Argia]. Idem, 20: 375–417.
'76. Synopsis des Agrionines. Le grande genre Agrion. Idem, 41: 247–322, 496–539, 1233–1309; 42: 490–531, 952–991.

Selys-Longchamps, Edm. de, and Hagen, H. A.
'54. Monographie des Caloptérygines. 291 pp., 14 pls.

Snodgrass, R. E.
'09. The thorax of insects and the articulation of the wings. Proc. U. S. Nat. Mus., 36: 511–595, pls. 40–69.

Thompson, O. S.
'08. Appendages of the second abdominal segment of male dragonflies (order Odonata). Bull. N. Y. State Mus., 124: 249–263, figs. 17–28.

Walsh, B. D.
'62. List of the Pseudoneuroptera of Illinois contained in the cabinet of the writer, with descriptions of over 40 new species, and notes on their structural affinities. Proc. Acad. Nat. Sci. Phila., 1862: 361–401.

Williamson, E. B.
'00. The dragonflies of Indiana. Dept. Geol. and Nat. Resources, Ind., Rep. 24: 233–333, pls. 1–7.
'00a. Notes on a few Wyoming dragonflies. Ent. News, 11: 453–458, pl. 9.
'12. *Hetaerina titia* and *tricolor* (dragonflies–Odonata). Ent. News, 23: 98–101.
'12a. The dragonfly *Argia moesta* and a new species (Odonata). Ent. News, 23: 196–203.

Wilson, C. B.
'09. Dragonflies of the Mississippi valley collected during the pearl mussel investigations on the Mississippi River, July and August 1907. Proc. U. S. Nat. Mus., 36: 653–671.

INDEX TO GENERA AND SPECIES

ABBREVIATIONS USED IN LETTERING PLATES

A,	anal vein
A_1–A_{11},	abdominal segments 1–11
aai,	anal appendages of adult–inferior
aas,	anal appendages of adult–superior
ag,	accessory genitalia of male
anc,	antenodal cross-veins
ant,	antennae
arc,	arculus
awp,	anterior wing-process
br,	bridge
bsp,	basilar space
C,	costa
cd,	cardo
ce,	compound eyes
ci,	cerci
cl,	cardella
cly,	clypeus
cr,	chitinous rod of the submentum
Cu_1, Cu_2,	cubitus–branches of
cw,	claws
cx,	coxa
cxp,	coxal process
dc,	dorsal carina
epcs,	epicranial furrow
epm,	epimeron
f,	front
fe,	femur
fi,	furcal invaginations
fl,	furcella
fs,	femoral setae
g,	gills–caudal
ga,	galea
gb,	genital lobe
gd,	gills–dorsal
glc,	galea-lacinia
gn,	genae
hm,	hamules
hp,	hypopharynx
ieps,	infraepisternum
insu,	interpleural suture
ints,	intersternum
lb,	labium
lbr,	labrum
lc,	lacinia
lk,	lateral keel
lp,	labial palpus
lp_1, lp_2,	labial palpus–first and second segments
ls,	lateral setae of labial palpus
M,	media
M_1,–M_4,	media, branches of the
mapl,	metapostscutellum
masl,	metascutellum
mc,	median cleft of the labium
mcp,	mesocoxal process
md,	mandible
me,	mentum
mfi,	mesofurcal invaginations
min,	microthorax, epimeron of the
ml,	median lobe of the labium
mopl,	mesopostscutellum
mosl,	mesoscutellum
mp,	metaphragma
mpf,	mesoprefurcal invaginations
mph,	mesophragma
mpp,	mesophragmal invaginations
ms,	mental setae
mscc,	mesoscutum–caudal portion
mscl,	mesoprescutum–cephalic portion of mesoscutum
mse,	marginal setae of the median lobe
msp,	mesothoracic spiracle
mssu,	mesopleural suture
mst,	mesosternum
mstg,	mesostigmal plates (caudal)
mstm,	mesosternellum
mstv,	mesostigmal plates (ventral)
mtcp,	metacoxal process
mtfi,	metafurcal invaginations
mtn,	metanotum
mtpf,	metaprefurca
mtsc,	metascutum
mtsl,	metathoracic spiracle
mtsm,	metasternellum
mtst,	metasternum
mtsu,	metapleural suture
mx,	maxilla
mxp,	maxillary palpus
nd,	nodus
o,	ocelli
oca,	caudal valves or gonapophyses
oce,	cephalic valves or gonapophyses
ocr,	occipital ridge
oct,	occiput
p,	paraptera
pa,	parameres
pcl,	pronotum–caudal lobe
pcp,	pronotum-cephalic lobe
pcxp,	procoxal process
pepn,	proepimeron
peps,	proepisternum
pg,	postgena
pl,	palpiger
pmc,	pronotum-median lobe

pn,	pronotum
pnc,	postnodal cross-veins
pps,	propleural suture
prs,	prostyles
prst,	presternum
ps,	penis
psct,	metaprescutum
psl,	prosternellum
pst,	mesopresternum
pta,	pretarsus
pwp,	posterior wing-process
qd,	quadrangle
R_1,	radius–first branch
Rs,	radial sector
Sc,	subcosta
Sc_1, Sc_2,	subcosta, branches of
seps,	supraepisternum
sm,	submentum
spn,	spring-vein
st,	stigma
sti_8,	sternites (caudal) of the eighth abdominal segment
stp,	stipes
sv,	seminal vesicle
t,	tentorium
ta,	tarsus
ti,	tibia
tic,	tibial comb
tm,	trochantin of mandible
tr,	trochanter
ts,	tibial setae
vx,	vertex
wc,	wing-case
wp,	wing process

Plate LVIII

Nymphal Structures

Fig. 1. *Enallagma* sp., cross-section of the head through the hypopharynx and maxillae.
Fig. 2. *Enallagma* sp., cross-section of the head caudad of the section shown in Figure 1.
Fig. 3. *Enallagma* sp., cross-section through the labium.
Fig. 4. *Enallagma* sp., longitudinal section of the head.
Fig. 5. *Lestes forcipatus*, anal segments and bases of gills.
Fig. 6. *Enallagma* sp., cross-section of labium near hinge.
Fig. 7. *Enallagma exsulans*, ventral aspect of the head with the labium folded back and the remaining mouth-parts in position.
Fig. 8. *Agrion maculatum*, labium.
Fig. 9. *Hetaerina americana*, labium.
Fig. 10. *Lestes forcipatus*, labium.
Fig. 11. *Argia violacea*, labium.
Fig. 12. *Ischnura verticalis*, labium.
Fig. 13. *Enallagma carunculatum*, labium.

Plate LVIII

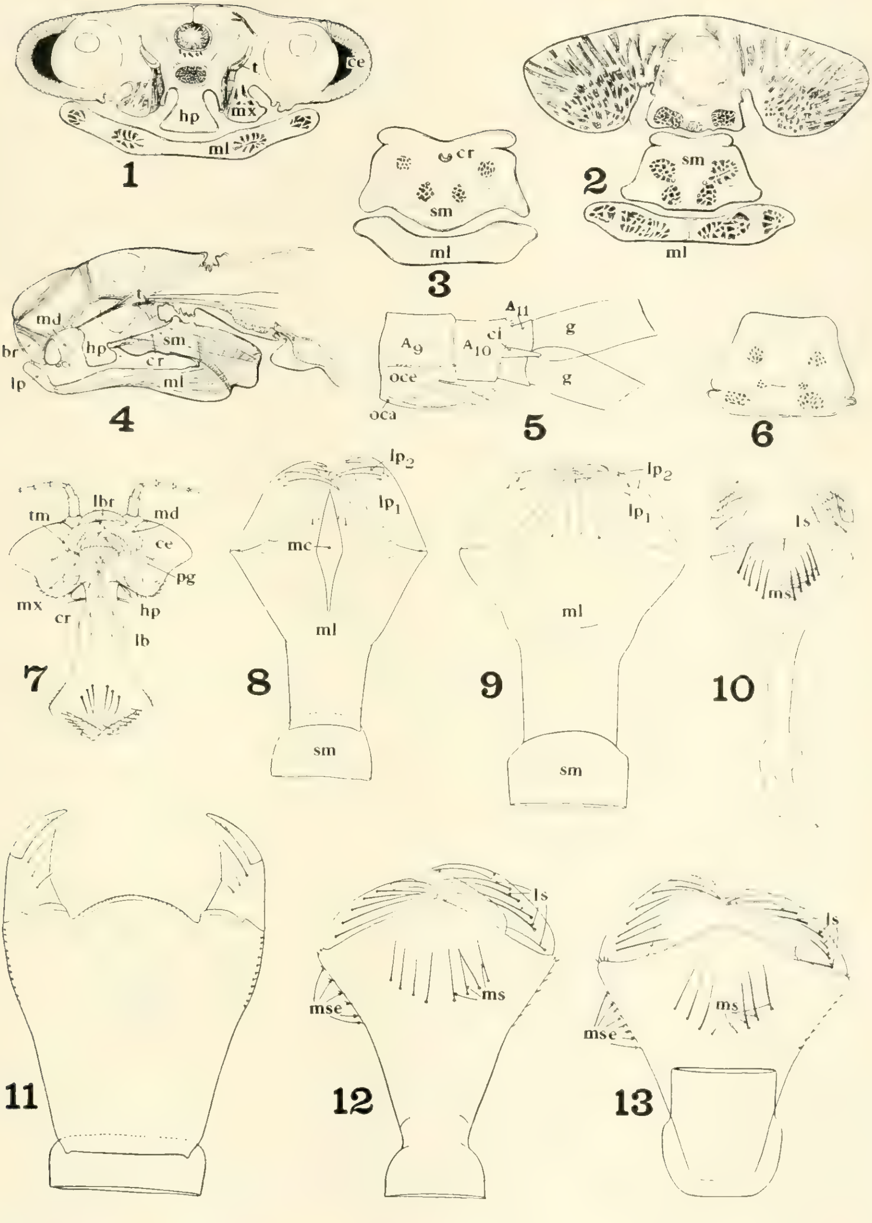
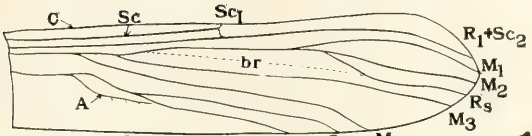

ce
t
hp
mx
ml
1
sm
ml
2
cr
sm
ml
3
t
md
lbr
hp
sm
cr
lp
ml
4
A_{11}
ci
g
A_9
A_{10}
oce
g
oca
5
6
lbr
tm
md
ce
pg
mx
hp
cr
lb
7
lp_2
lp_1
mc
ml
sm
8
lp_2
lp_1
ml
sm
9
ls
ms
10
11
ls
ms
mse
12
ls
ms
mse
13

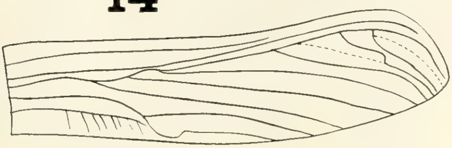
Plate LIX

Nymphal Structures

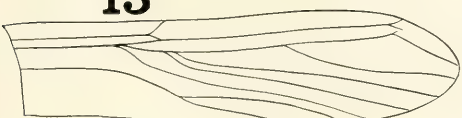
Fig. 14. *Lestes rectangularis,* wing-case.
Fig. 15. *Hetaerina americana,* wing-case.
Fig. 16. *Enallagma signatum,* wing-case.
Fig. 17. The same, young nymph, wing-case.
Fig. 18. *Ischnura verticalis,* caudal end of the abdomen with the two lateral gills removed.
Fig. 19. *Enallagma exsulans,* tarsus.
Fig. 20. The same, leg.
Fig. 21. *Ischnura verticalis,* dorsum of meso- and metathorax.
Fig. 22. *Agrion maculatum,* maxilla.
Fig. 23. *Hetaerina americana,* dorsum of the prothorax.
Fig. 24. *Ischnura verticalis,* ventral aspect of thorax and cephalic segments of abdomen.
Fig. 25. The same, lateral aspect of thorax and abdomen.
Fig. 26. *Enallagma* sp., cross-section of gills.



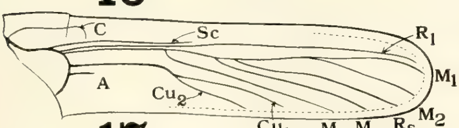
14



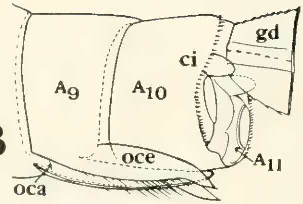
15



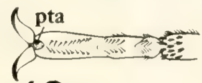
16



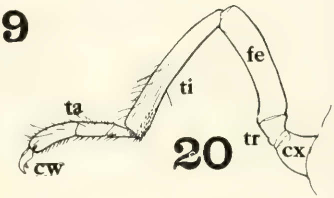
17



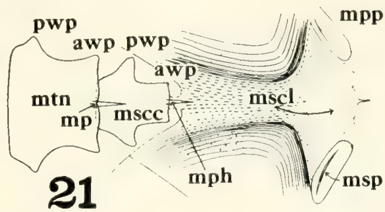
18



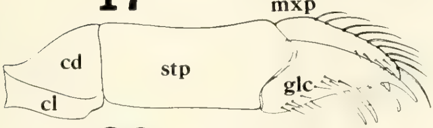
19



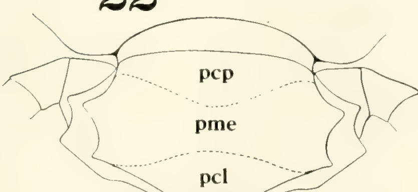
20



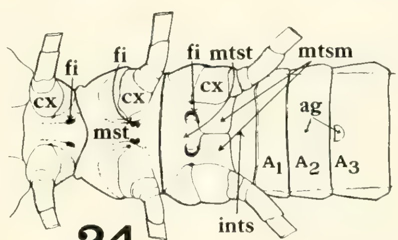
21



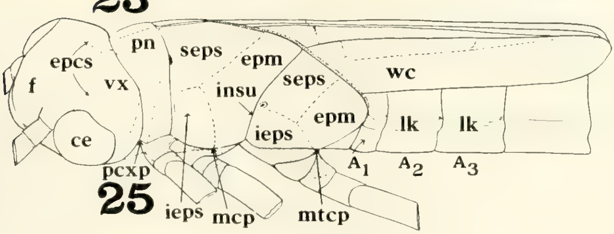
22



23



24



25

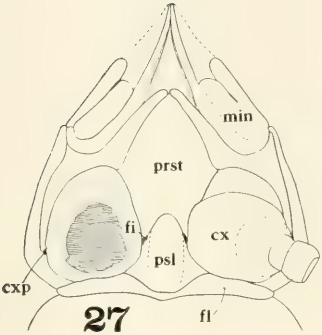
26

Plate LX

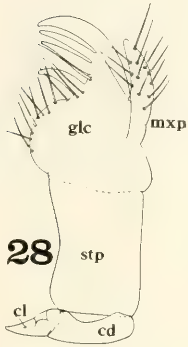
Nymphal and Adult Structures

Fig. 27. *Ischnura verticalis,* adult, ventral aspect of prothorax.
Fig. 28. The same, adult, maxilla.
Fig. 29. *Hetaerina americana,* adult, ventral aspect of prothorax.
Fig. 30. *Ischnura verticalis,* adult, caudal aspect of head.
Fig. 31. Plecoptera nymph, maxilla.
Fig. 32. *Ischnura verticalis,* adult, cephalic aspect of head.
Fig. 33. *Hetaerina americana,* adult, ventral view of the second abdominal segment of the male.
Fig. 34. The same, adult, anal appendages, dorsal view.
Fig. 35. *Ischnura verticalis,* adult, leg.
Fig. 36. The same, adult, lateral view of prothorax.
Fig. 37. The same, adult, labium.
Fig. 38. *Hetaerina americana,* adult, lateral view of anal appendages.
Fig. 39. The same, adult, lateral view of prothorax.

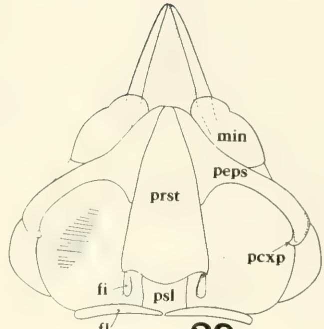
Plate LX



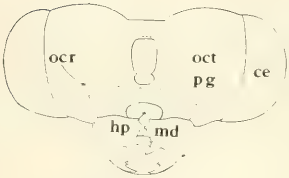
27



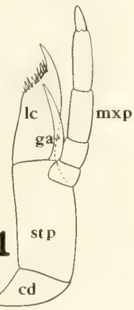
28



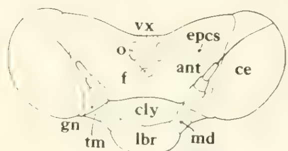
29



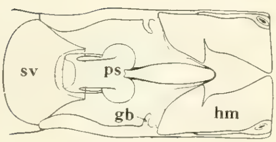
30



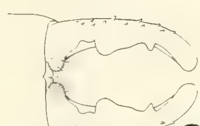
31



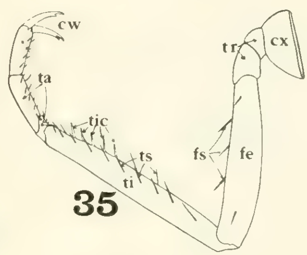
32



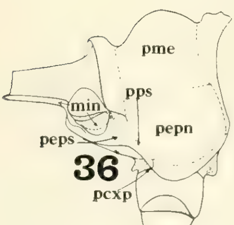
33



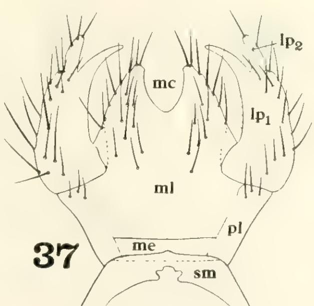
34



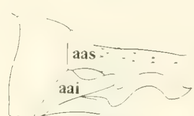
35



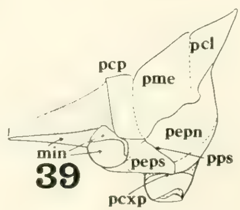
36



37



38



39

Plate LXI

Thoracic Structures of Adults

Fig. 40. *Hetaerina americana*, ventral aspect of the meso- and metathorax.

Fig. 41. *Hetaerina titia*, dorsal aspect of meso- and metathorax.

Fig. 42. *Ischnura verticalis*, ventral aspect of meso- and metathorax.

Fig. 43. The same, lateral aspect of meso- and metathorax.

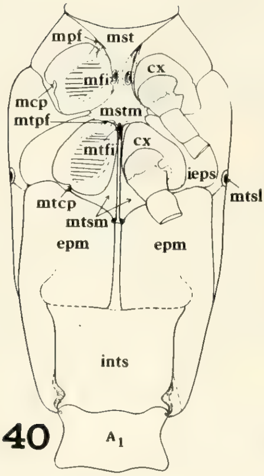
Fig. 44. The same, dorsal aspect of meso- and metathorax.

Fig. 45. *Hetaerina americana*, lateral aspect of meso- and metathorax.

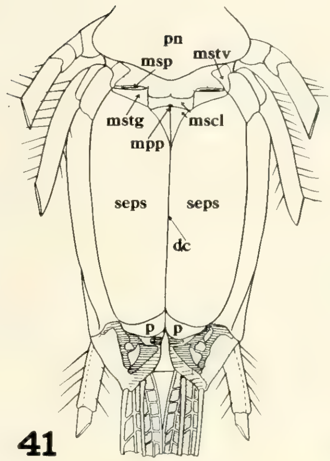
Fig. 46. The same, dorsal view of meso- and metaterga.

Fig. 47. *Ischnura verticalis*, dorsal view of meso- and metaterga.

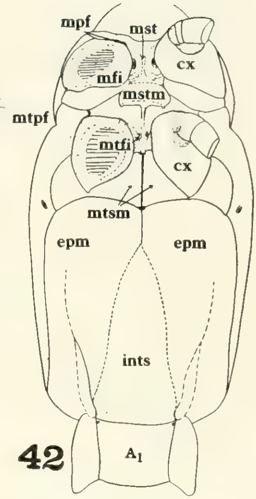
PLATE LXI



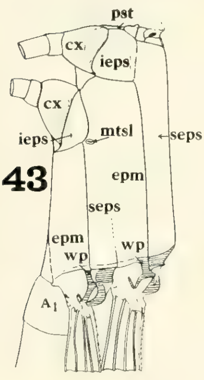
40



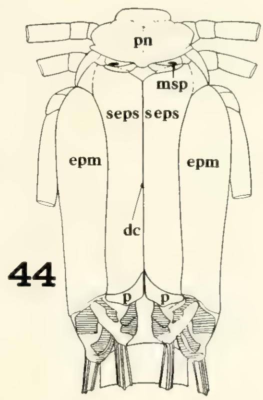
41



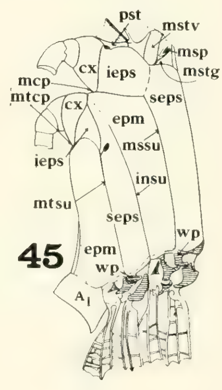
42



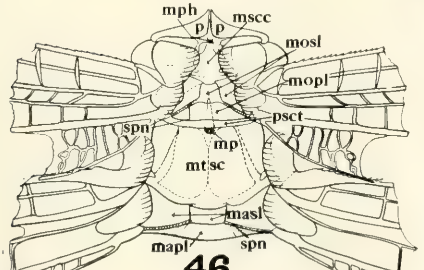
43



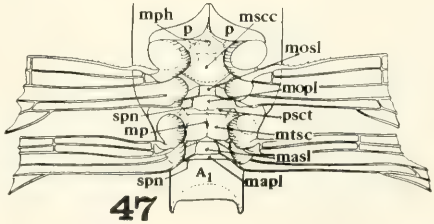
44



45



46



47

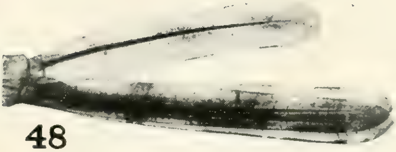
Plate LXII

*Caudal Gills of Nymphs**

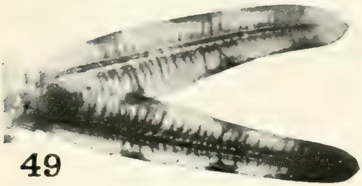
Fig. 48. *Lestes vigilax.*
Fig. 49. *Lestes forcipatus.*
Fig. 50. *Lestes congener.*
Fig. 51. *Lestes unguiculatus,* normal gills.
Fig. 52. The same, dark gills.
Fig. 53. *Enallagma exsulans.*
Fig. 54. *Enallagma antennatum.*
Fig. 55. *Enallagma traviatum.*
Fig. 56. *Enallagma signatum.*
Fig. 57. *Enallagma pollutum.*

*One of the lateral gills removed in most cases.

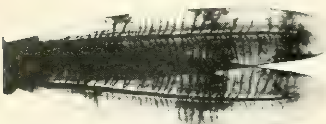
Plate LXII



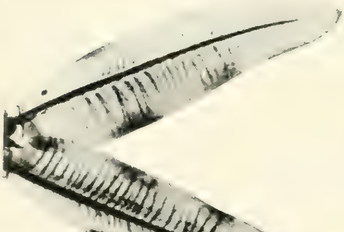
48



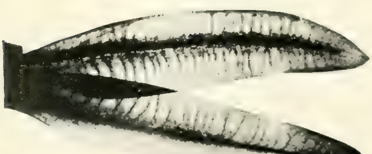
49



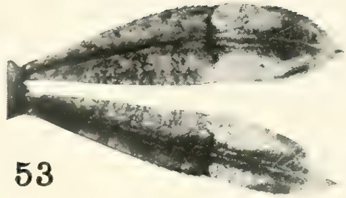
50



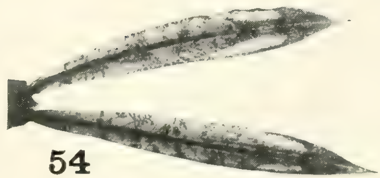
51



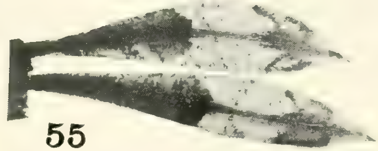
52



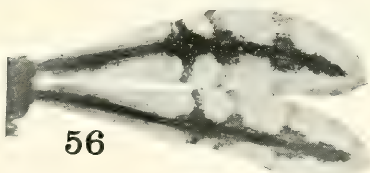
53



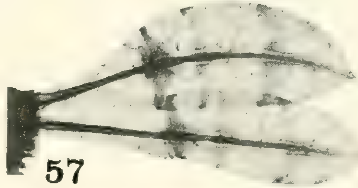
54



55



56



57

Plate LXIII

*Caudal Gills of Nymphs**

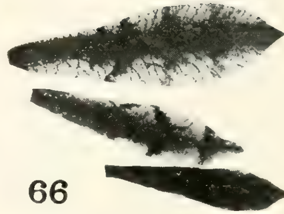
Fig. 58. *Argia moesta putrida.*
Fig. 59. *Amphiagrion saucium.*
Fig. 60. *Anomalagrion hastatum.*
Fig. 61. *Nehalennia irene.*
Fig. 62. *Ischnura verticalis.*
Fig. 63. *Argia violacea.*
Fig. 64. *Ischnura posita.*
Fig. 65. *Ischnura verticalis,* young nymph.
Fig. 66. *Ischnura posita.*
Fig. 67. *Argia apicalis.*
Fig. 68. *Argia tibialis.*
Fig. 69. *Enallagma signatum,* variations in pigmentation.

*One of the lateral gills removed in cases where the gills are attached to the abdomen.

Plate LXIII


58

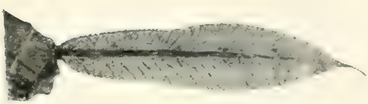

63

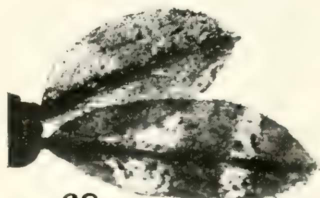

66

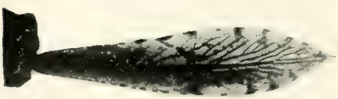

59

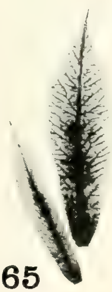

64


67


60


68


61


65


62

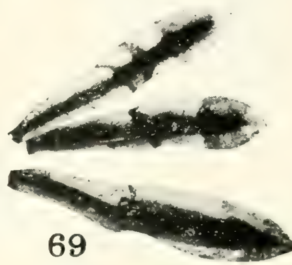
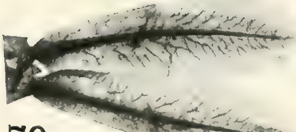

69

Plate LXIV

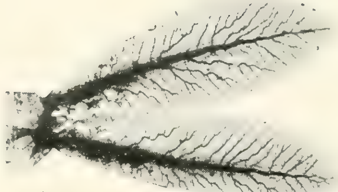
Caudal Gills of Nymphs and Wings of Adults*

Fig. 70. *Enallagma carunculatum,* gills.
Fig. 71. *Enallagma cyathigerum,* gills.
Fig. 72. *Enallagma geminatum,* gills.
Fig. 73. *Agrion aequabile,* wings.
Fig. 74. *Hetaerina americana,* wings.
Fig. 75. *Enallagma civile,* gills.
Fig. 76. *Enallagma hageni,* gills.
Fig. 77. *Enallagma exsulans,* dark and light gills.
Fig. 77a. The same, abnormal gills.
Fig. 78. *Hetaerina americana,* male, wings.
Fig. 79. The same, nymphal skin.
Fig. 80. *Enallagma* (?) *calverti,* lateral gill.

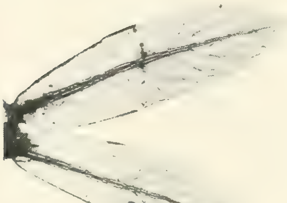
*One of the lateral gills removed in cases where the gills are attached to the abdomen.



70



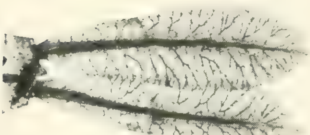
75



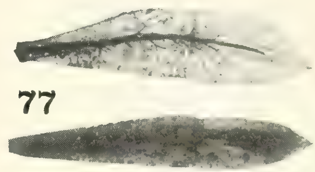
71

79

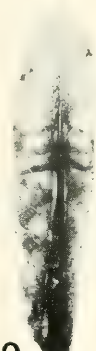
76



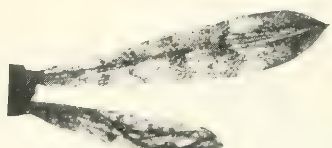
72



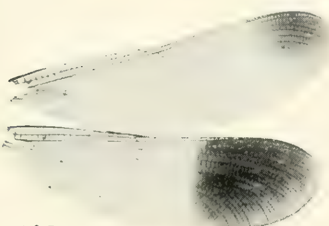
77



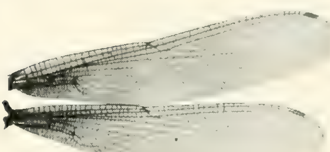
80



77a



73



74

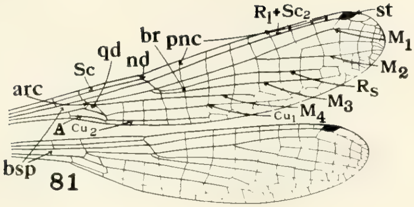
78

Plate LXV

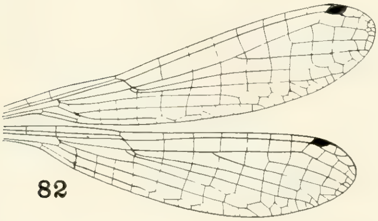
Wings of Adults

Fig. 81. *Ischnura verticalis.*
Fig. 82. *Anomalagrion hastatum,* female.
Fig. 83. The same, male.
Fig. 84. *Chromagrion conditum.*
Fig. 85. *Lestes rectangularis.*
Fig. 86. *Ischnura posita.*
Fig. 87. *Enallagma hageni.*
Fig. 88. *Nehalennia irene.*
Fig. 89. *Amphiagrion saucium.*
Fig. 90. *Argia apicalis.*

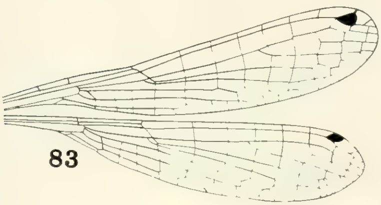
PLATE LXV



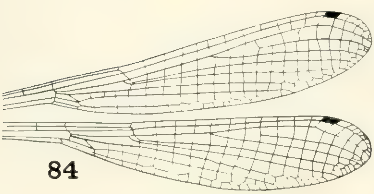
81



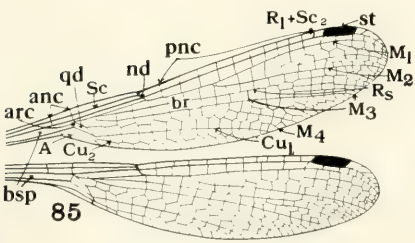
82



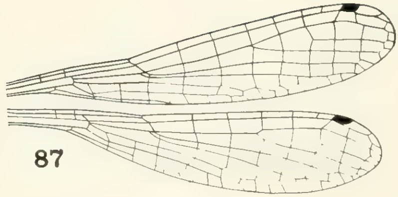
83



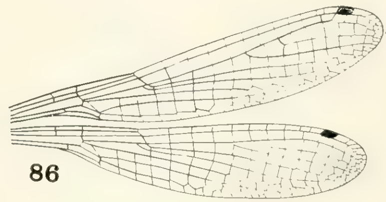
84



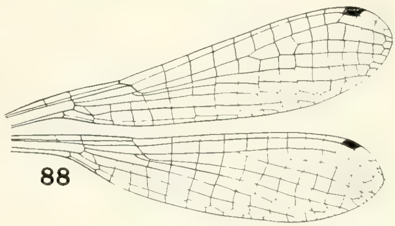
85



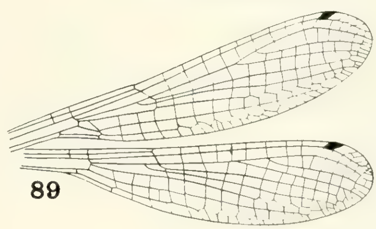
87



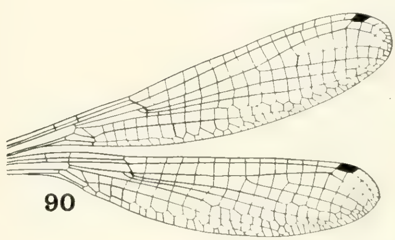
86



88



89



90

Plate LXVI

Abdominal Structures of Adults

Fig. 91. *Enallagma carunculatum*, female, dorsal view of abdomen.
Fig. 92. *Enallagma civile*, female, dorsal view of abdomen.
Fig. 93. *Enallagma cyathigerum*, female, dorsal view of abdomen.
Fig. 94. *Enallagma traviatum*, female, dorsal view of abdomen.
Fig. 95. *Enallagma aspersum*, female, dorsal view of abdomen.
Fig. 96. *Enallagma geminatum*, female, dorsal view of abdomen.
Fig. 97. *Enallagma carunculatum*, male, penis.
Fig. 98. *Enallagma cyathigerum*, male, penis.
Fig. 99. *Enallagma carunculatum*, female, caudal abdominal segments.
Fig. 100. *Anomalagrion hastatum*, female, caudal abdominal segments.
Fig. 101. *Enallagma hageni*, male, penis.
Fig. 102. *Chromagrion conditum*, male, anal appendages.
Fig. 103. *Enallagma civile*, male, anal appendages.
Fig. 104. *Ischnura verticalis*, female, caudal abdominal segments.
Fig. 105. *Enallagma civile*, male, penis.
Fig. 106. *Chromagrion conditum*, male anal appendages.
Fig. 107. *Enallagma ebrium*, male, penis.
Fig. 108. *Enallagma calverti*, male, penis.

Plate LXVI

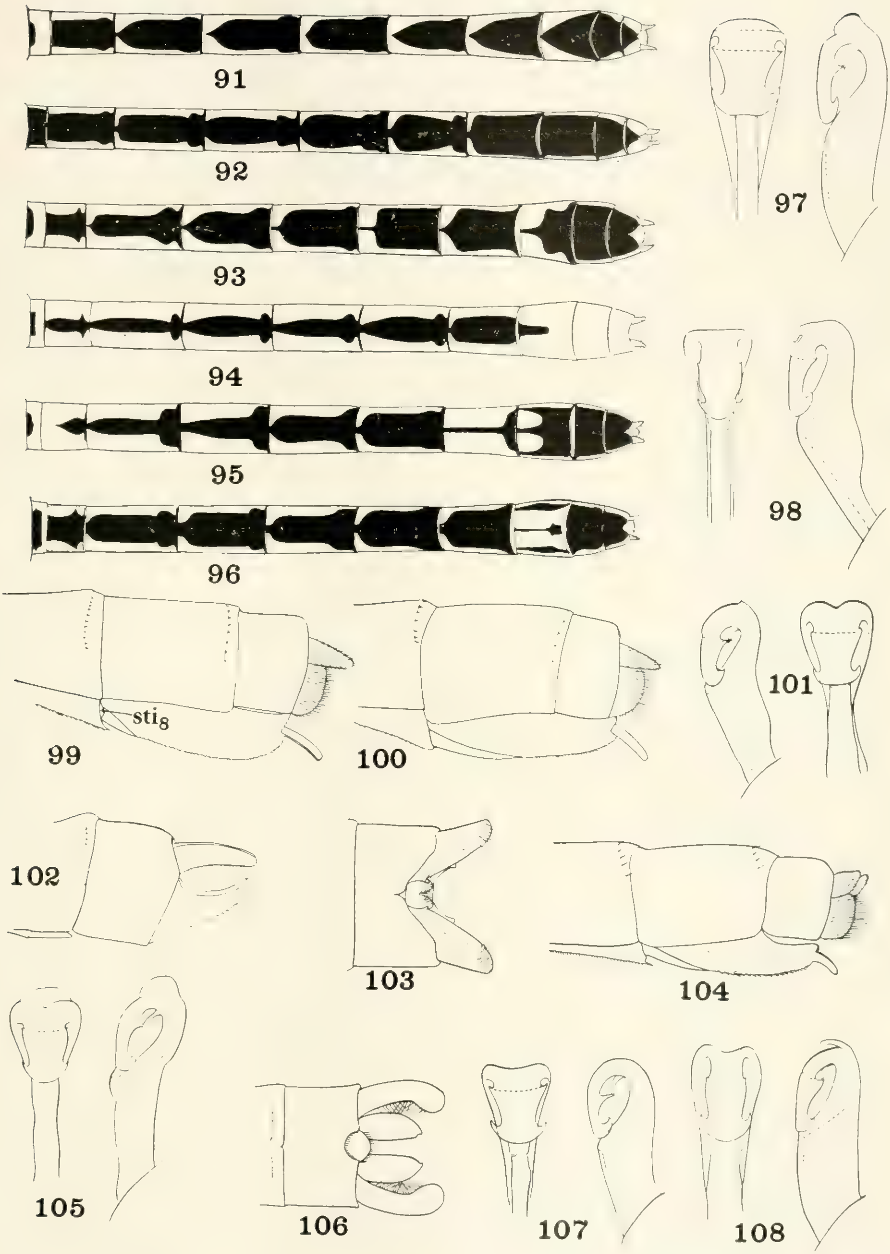
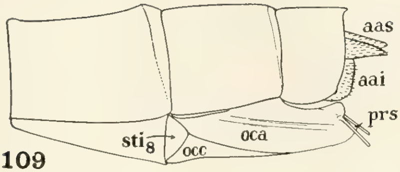


Plate LXVII

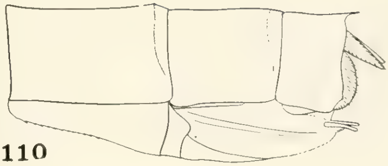
Abdominal Structures of Adults

Fig. 109. *Agrion maculatum,* female, caudal end of abdomen.
Fig. 110. *Agrion aequabile,* female, caudal end of abdomen.
Fig. 111. *Hetaerina titia,* female, caudal end of abdomen.
Fig. 112. *Hetaerina americana,* female, caudal end of abdomen.
Fig. 113. *Lestes uncatus,* female, caudal end of abdomen.
Fig. 114. *Lestes forcipatus,* female, caudal end of abdomen.
Fig. 115. *Lestes rectangularis,* female, caudal end of abdomen.
Fig. 116. *Argia moesta putrida,* female, caudal end of abdomen.
Fig. 117. *Agrion aequabile,* male, anal appendages.
Fig. 118. The same, male, sternum of the ninth segment.
Fig. 119. *Hetaerina titia,* male, anal appendages.
Fig. 120. *Lestes disjunctus,* male, second abdominal segment, from side.
Fig. 121. *Hetaerina americana,* male, sternum of the ninth segment.
Fig. 122. *Lestes forcipatus,* male, second abdominal segment, lateral view.

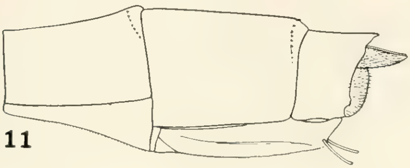
Plate LXVII



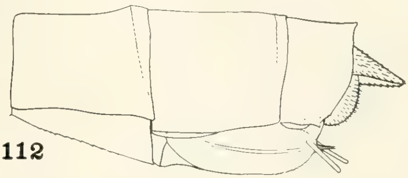
109



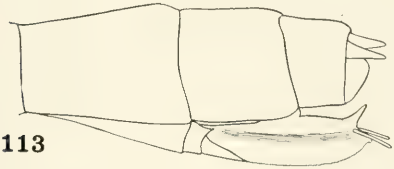
110



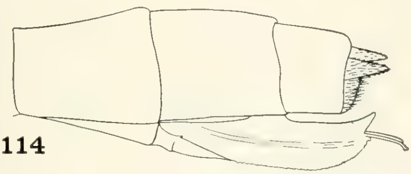
111



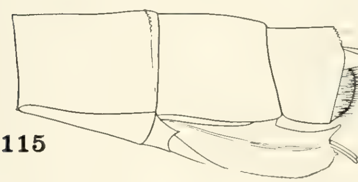
112



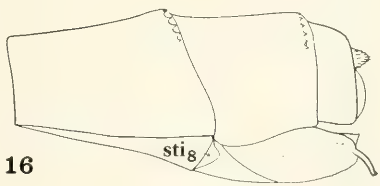
113



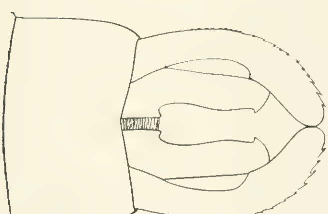
114



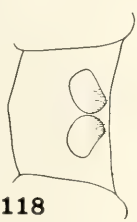
115



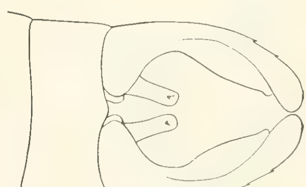
116



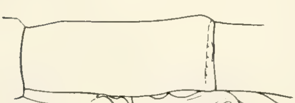
117



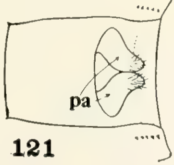
118



119



120



121

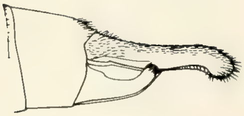
122

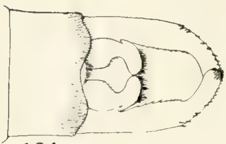
Plate LXVIII

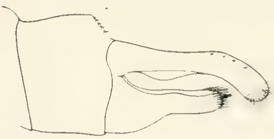
Anal Appendages of Adults

Fig. 123. *Lestes congener.*
Fig. 124. *Lestes congener.*
Fig. 125. *Lestes unguiculatus.*
Fig. 126. *Lestes unguiculatus.*
Fig. 127. *Lestes rectangularis.*
Fig. 128. *Lestes rectangularis.*
Fig. 129. *Lestes vigilax.*
Fig. 130. *Lestes vigilax.*
Fig. 131. *Lestes inaequalis.*
Fig. 132. *Lestes inaequalis.*
Fig. 133. *Lestes disjunctus.*
Fig. 134. *Agrion aequabile.*
Fig. 135. *Lestes uncatus.*
Fig. 136. *Lestes uncatus.*
Fig. 137. *Lestes forcipatus.*
Fig. 138. *Lestes forcipatus.*
Fig. 139. *Agrion maculatum.*
Fig. 139a. *Agrion maculatum.*

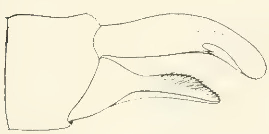
PLATE LXVIII

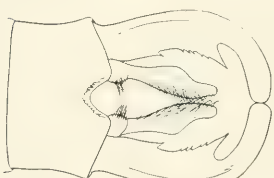

123

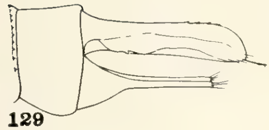

124

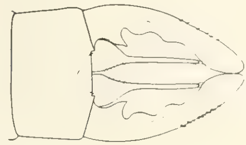

125

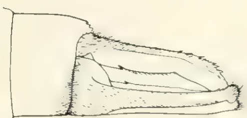

126

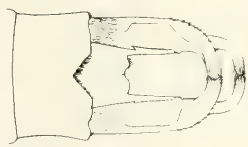

127


128

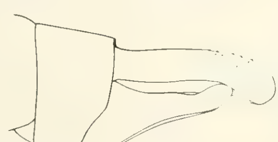

129

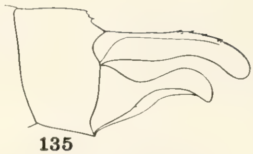

130

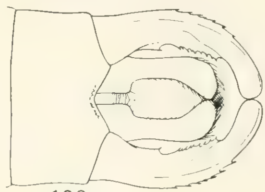

131

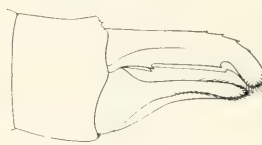

132

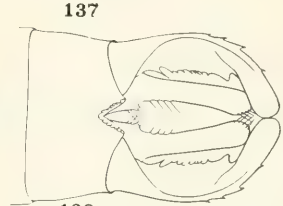

133

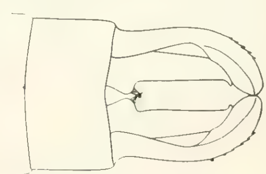

134


135


136


137


138


139

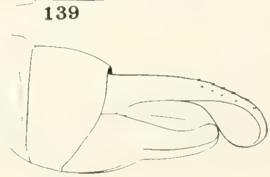
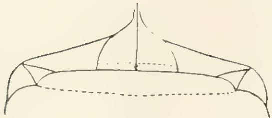

139

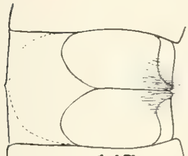
Plate LXIX

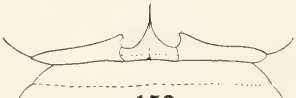
Thoracic and Abdominal Structures of Adults

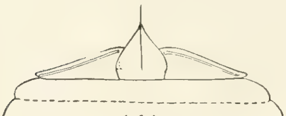
Fig. 140. *Argia tibialis,* female, mesostigmal plates.
Fig. 141. *Argia sedula,* female, mesostigmal plates.
Fig. 142. *Argia violacea,* female, mesostigmal plates.
Fig. 143. *Argia fumipennis,* male, anal appendages.
Fig. 144. The same, male, anal appendages.
Fig. 145. *Argia violacea,* male, anal appendages.
Fig. 146. The same, male, anal appendages.
Fig. 147. *Argia apicalis,* male, ninth sternum.
Fig. 148. *Argia fumipennis,* female, mesostigmal plates.
Fig. 149. *Argia sedula,* male, anal appendages.
Fig. 150. The same, male, anal appendages.
Fig. 151. *Argia apicalis,* male, anal appendages.
Fig. 152. The same, male, anal appendages.
Fig. 153. The same, female, mesostigmal plates.
Fig. 154. *Argia moesta putrida,* female, mesostigmal plates.
Fig. 155. *Argia tibialis,* male, anal appendages.
Fig. 156. The same, male, anal appendages.
Fig. 157. *Argia moesta putrida,* male, anal appendages.
Fig. 158. The same, male, anal appendages.

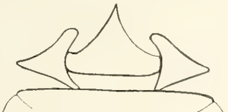
PLATE LXIX

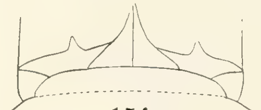

140

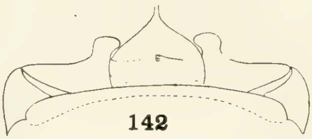

147

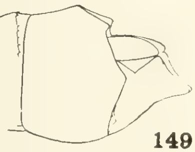

153

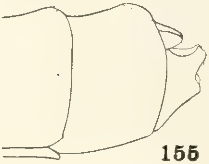

141

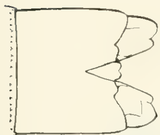

148


154

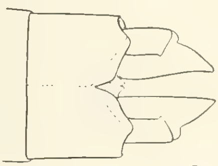

142

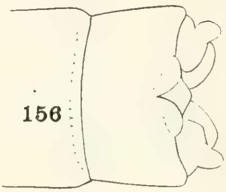

149

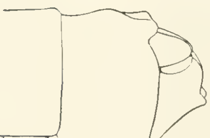

155

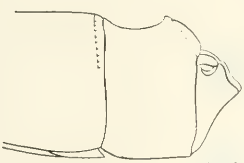

143

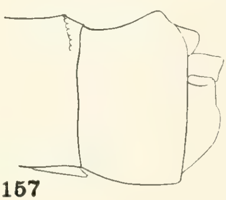

144

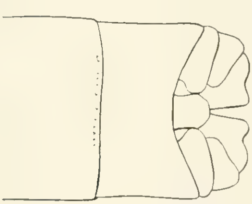

150

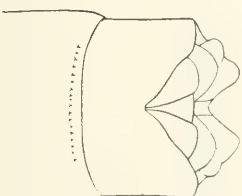

156


145


151


157


146


152

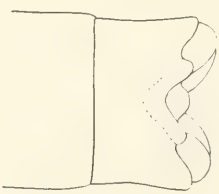

158

Plate LXX

Thoracic and Abdominal Structures of Adults

Fig. 159. *Nehalennia irene,* male, anal appendages.
Fig. 160. The same, male, anal appendages.
Fig. 161. *Enallagma hageni,* male, anal appendages.
Fig. 162. The same, male, anal appendages.
Fig. 163. *Ischnura posita,* female, mesostigmal plates.
Fig. 164. *Anomalagrion hastatum,* female, mesostigmal plates.
Fig. 165. *Enallagma aspersum,* male, ninth sternum.
Fig. 166. *Anomalagrion hastatum,* male, anal appendages.
Fig. 167. The same, male, anal appendages.
Fig. 168. *Ischnura verticalis* male, anal appendages.
Fig. 169. *Enallagma doubledayi,* male, right superior appendage seen from the left and above.
Fig. 170. *Chromagrion conditum,* female, mesostigmal plates and dorsum of prothorax.
Fig. 171. *Ischnura posita,* male, ninth sternum.
Fig. 172. *Anomalagrion hastatum,* male, ninth sternum.
Fig. 173. *Ischnura posita,* male, anal appendages.
Fig. 174. *Amphiagrion saucium,* male, anal appendages.
Fig. 175. *Enallagma doubledayi,* male, anal appendages.
Fig. 176. *Enallagma carunculatum,* male, right superior appendage seen from the left and above.
Fig. 177. *Ischnura posita,* male, anal appendages.
Fig. 178. *Amphiagrion saucium,* male, anal appendages.
Fig. 179. *Enallagma civile,* male, right superior appendage seen from the left and above.
Fig. 180. *Ischnura verticalis,* female, mesostigmal plates.
Fig. 181. *Amphiagrion saucium,* female, mesostigmal plates.
Fig. 182. *Nehalennia irene,* female, mesostigmal plates.
Fig. 183. The same, male, ninth abdominal sternum.

PLATE LXX

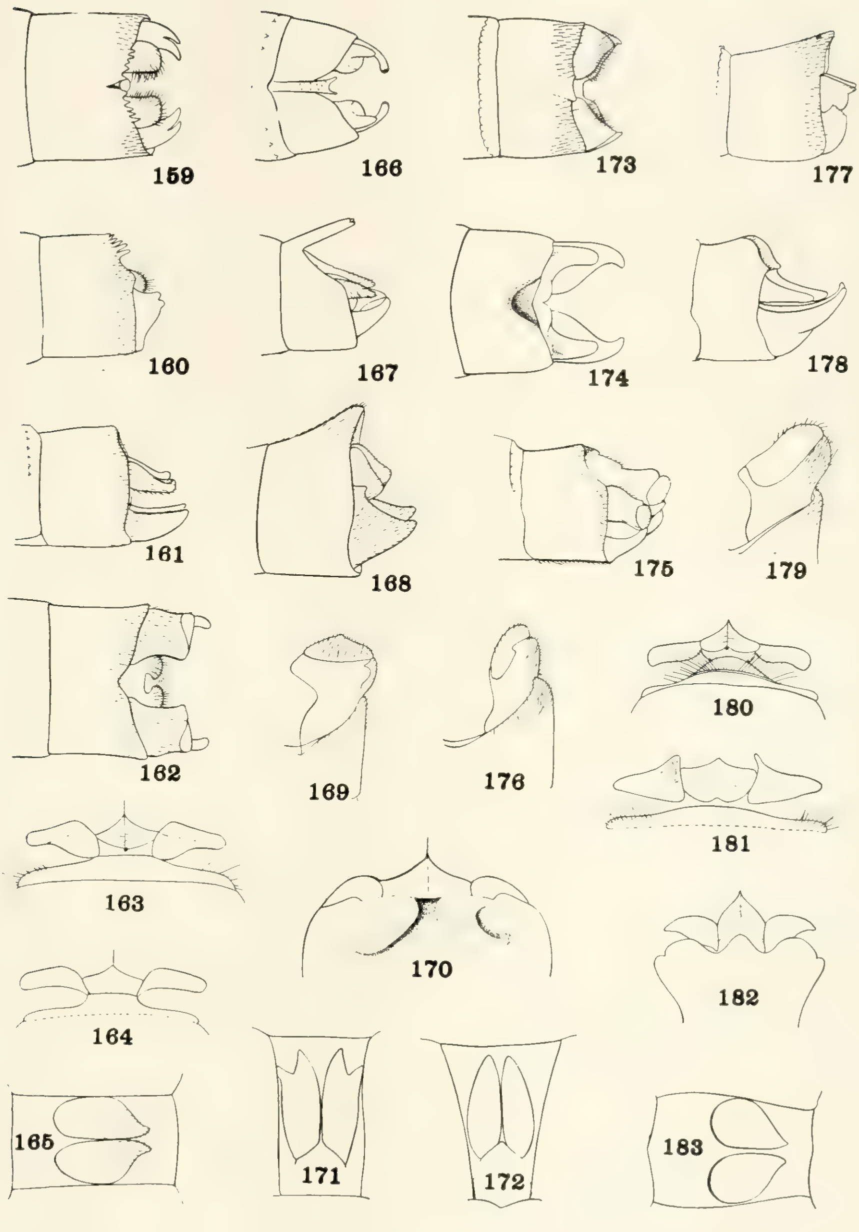
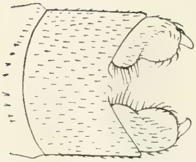

159
166
173
177
160
167
174
178
161
168
175
179
162
169
176
180
181
163
170
182
164
165
171
172
183

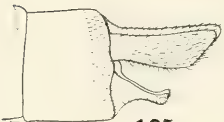
Plate LXXI

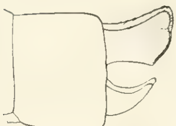
Anal Appendages of Adults

Fig. 184. *Ischnura kellicotti.*
Fig. 185. *Enallagma signatum.*
Fig. 186. *Enallagma pollutum.*
Fig. 187. *Enallagma carunculatum.*
Fig. 188. *Enallagma aspersum.*
Fig. 189. *Enallagma ebrium.*
Fig. 190. *Enallagma divagans.*
Fig. 191. *Ischnura kellicotti.*
Fig. 192. *Enallagma signatum.*
Fig. 193. *Enallagma pollutum.*
Fig. 194. *Enallagma carunculatum.*
Fig. 195. *Enallagma aspersum.*
Fig. 196. *Enallagma ebrium.*
Fig. 197. *Enallagma divagans.*
Fig. 198. *Enallagma civile.*
Fig. 199. *Enallagma traviatum.*
Fig. 200. *Enallagma calverti.*
Fig. 201. *Enallagma cyathigerum.*
Fig. 202. *Enallagma antennatum.*
Fig. 203. *Enallagma exsulans.*
Fig. 204. *Enallagma geminatum.*
Fig. 205. *Enallagma carunculatum.*
Fig. 206. *Enallagma traviatum.*
Fig. 207. *Enallagma calverti.*
Fig. 208. *Enallagma cyathigerum.*
Fig. 209. *Enallagma antennatum.*
Fig. 210. *Enallagma exsulans.*
Fig. 211. *Enallagma geminatum.*

PLATE LXXI

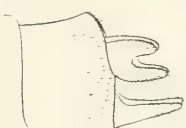

184


185

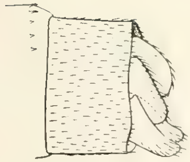

186

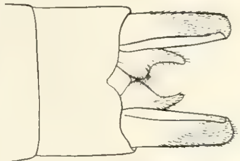

187

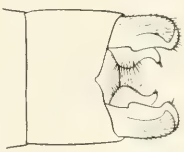

188

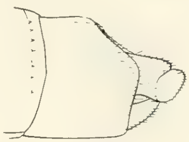

189

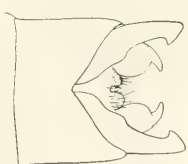

190

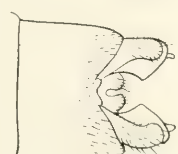

191


192

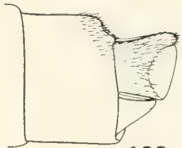

193

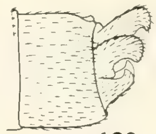

194

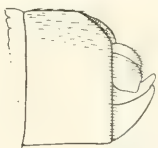

195

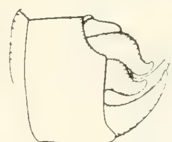

196


197

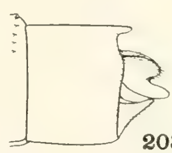

198

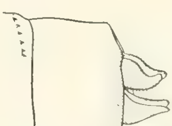

199

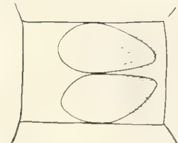

200

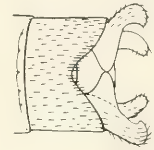

201

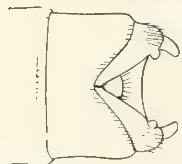

202

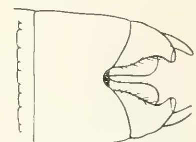

203


204

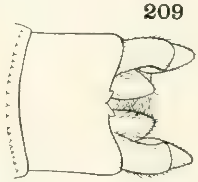

205


206


207


208


209


210

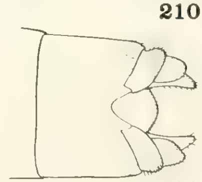

211

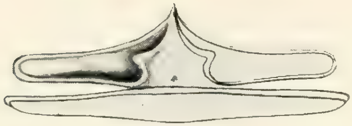
Plate LXXII

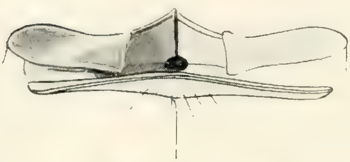
Thoracic Structures of Adults

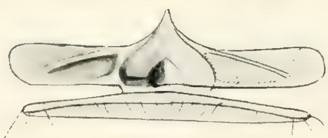
Fig. 212. *Enallagma civile,* mesostigmal plates.
Fig. 213. *Enallagma cyathigerum,* mesostigmal plates.
Fig. 214. *Enallagma signatum,* mesostigmal plates.
Fig. 215. *Enallagma carunculatum,* mesostigmal plates.
Fig. 216. *Enallagma geminatum,* mesostigmal plates.
Fig. 217. *Ischnura verticalis,* nymph. (See Plate LXXIII.)
Fig. 218. *Enallagma traviatum,* mesostigmal plates.
Fig. 219. *Enallagma antennatum,* mesostigmal plates.
Fig. 220. *Enallagma exsulans,* mesostigmal plates.
Fig. 221. *Enallagma hageni,* mesostigmal plates.
Fig. 222. *Agrion maculatum,* nymph. (See Plate LXXIII.)
Fig. 223. *Enallagma calverti,* mesostigmal plates.
Fig. 224. *Enallagma divagans,* mesostigmal plates.
Fig. 225. *Enallagma pollutum,* mesostigmal plates.
Fig. 226. *Enallagma doubledayi,* mesostigmal plates.
Fig. 227. *Enallagma ebrium,* mesostigmal plates.
Fig. 228. *Lestes forcipatus,* nymph. (See Plate LXXIII.)

PLATE LXXII

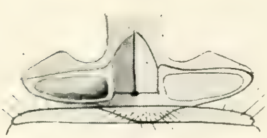

212

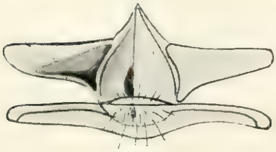

213

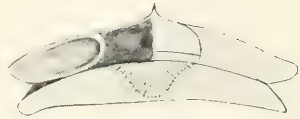

214


215


216

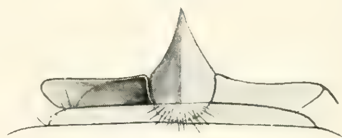

218

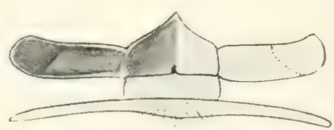

219

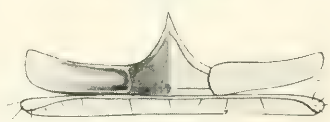

220


221


223


224


225


226


227

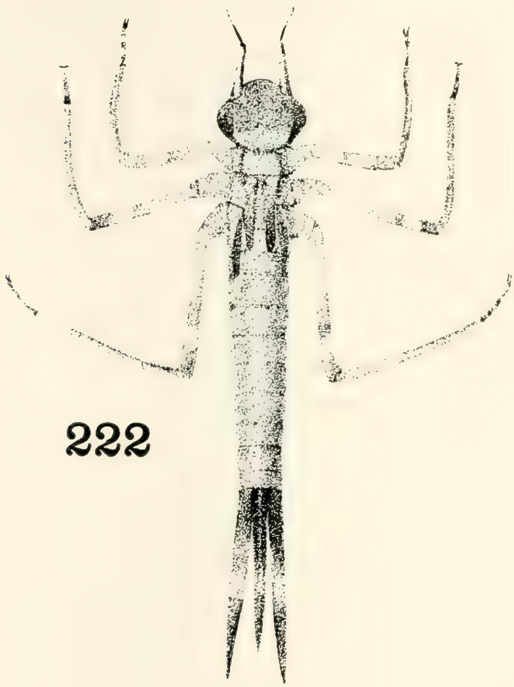
PLATE LXXIII

Nymphs

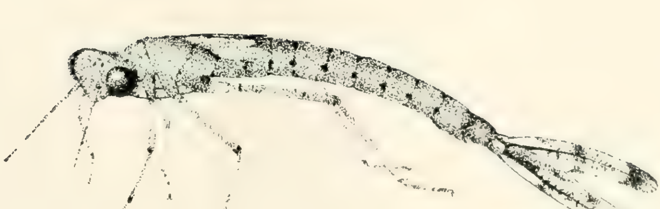
Fig. 217. *Ischnura verticalis.*
Fig. 222. *Agrion maculatum.*
Fig. 228. *Lestes forcipatus.*

PLATE LXXIII

217



222



228

Bulletin

of the

Illinois State Laboratory

of

Natural History

Urbana, Illinois, U. S. A.

Vol. XII. August 1918 Contents and Index

1915, 1916, 1917

INDEX.

D

E

F

G

M

N

S

U

V

W